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A RESOURCE INVENTORY METHOD

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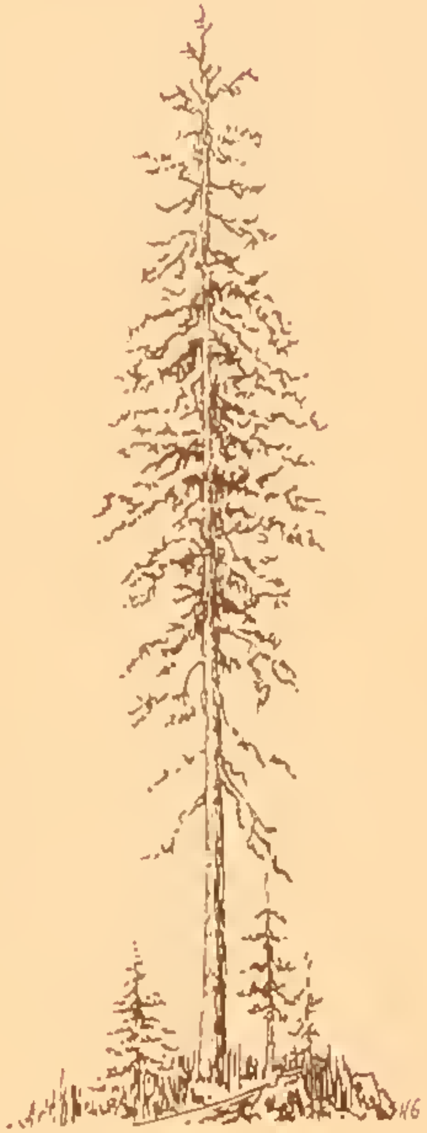
Little Brown Church
Well-Known Cultural Landmark in the Bigfork Study Area

A RESOURCE INVENTORY METHOD

FOR LAND USE PLANNING IN MONTANA



Prepared by

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PREFACE

In Montana we have a special closeness to the land. It has made us what we are; its use in the coming years will determine what we become.

Yet this special relationship has not always prevented us from abusing our limited land resource. In some cases natural values have been inadvertently damaged or destroyed because they were not properly identified before development proceeded.

In recognition of this problem, a cooperative effort was initiated in July 1972, between the Montana Department of Natural Resources and Conservation and the Montana Department of Intergovernmental Relations, Division of Planning and Economic Development. The objective was to develop natural resource inventory procedures which would facilitate the use of such information in the planning process.

The study upon which this report is based was made possible by a planning grant which the Division of Planning and Economic Development received from the U. S. Department of Housing and Urban Development. The project was then subcontracted to the Department of Natural Resources and Conservation, which contributed additional support in the form of services.

A 15,040 acre area near Bigfork was selected for the project because it contains a diversity of natural values and land uses, and because sufficient data exists to illustrate a wide variety of natural capabilities and limitations. In addition, the rapid conversion from forestry and agricultural uses to recreational land development occurring in this scenic, water-dominated region may qualify it as an environmentally critical area.

No particular land use recommendations are made with respect to any part of the Bigfork study area, nor has a plan for the area been formulated. The actual data collected, interpreted and analyzed is of secondary importance and is presented only to illustrate the inventory methods employed.

The application of this inventory method to land use planning should help to maintain the special way of life we enjoy in Montana.

Gary J. Wicks

GARY J. WICKS, DIRECTOR
MONTANA DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION

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The idea for the land capability study came from Hal Price and Jim Richard, Montana Division of Planning and Economic Development, who were instrumental in securing the project grant.

Special thanks are in order to the many property owners of the Bigfork study area who have cooperated in this study by allowing researchers access to their lands and by providing local information on climate, history, land use and wildlife.

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An office was provided in Kalispell for the duration of the field study by Jim Gragg, Forestry Division of the Montana Department of Natural Resources and Conservation.

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PHOTOS

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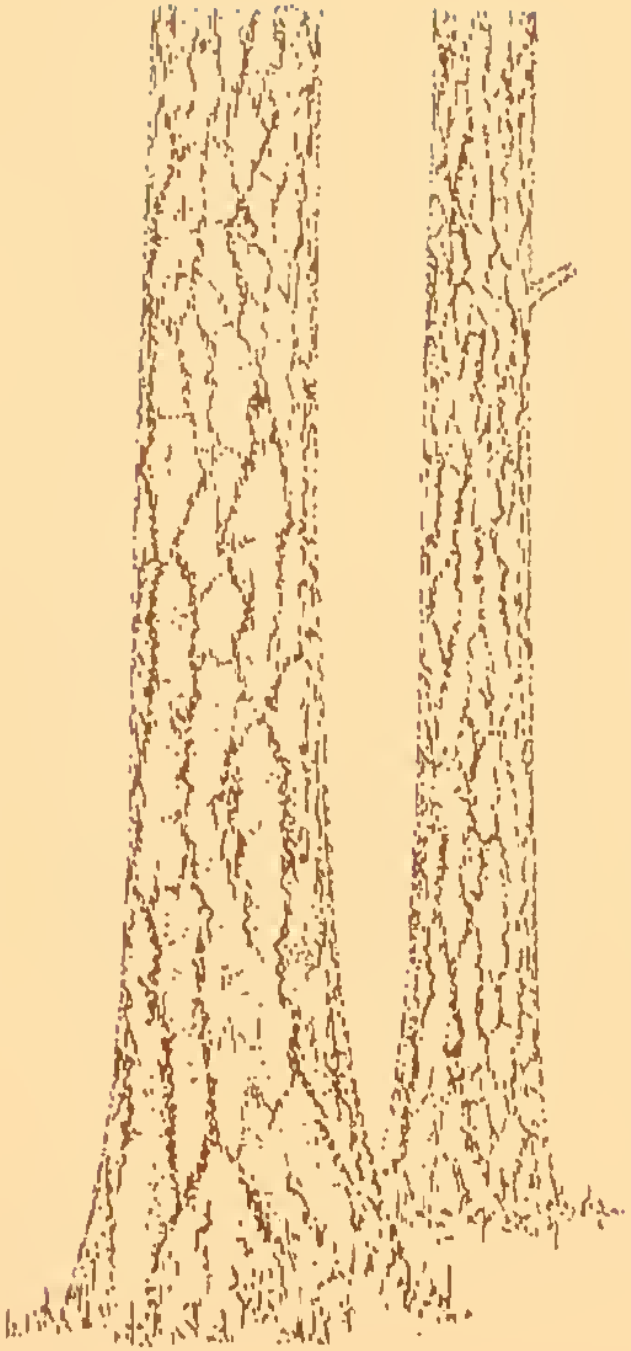

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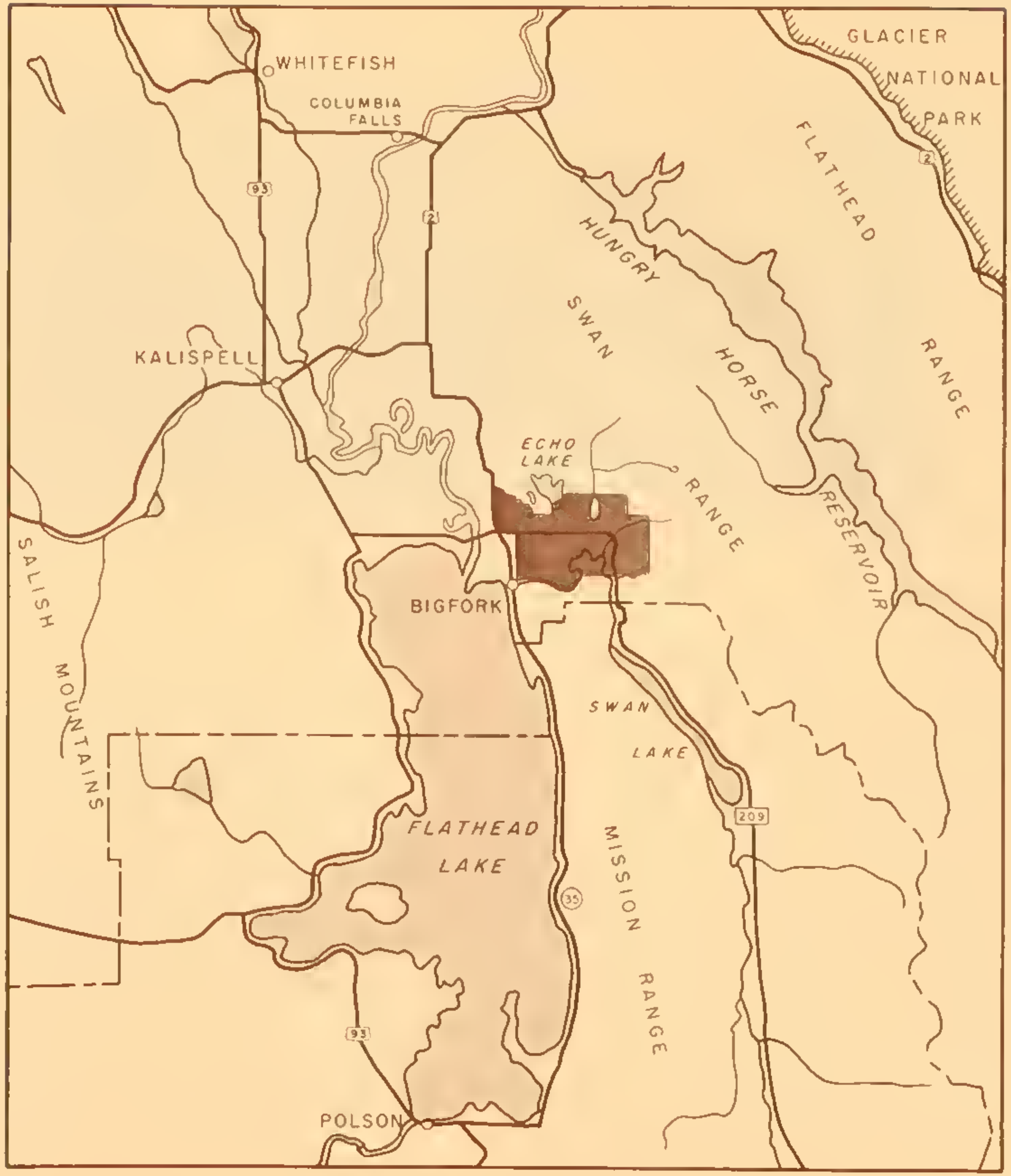
INTRODUCTION



Location of Bigfork Study Area in its Regional Setting

The primary objective of this study was to develop and field test a method of natural resource inventory and analysis for land use planning. This objective has been approached from the standpoint of two potential applications: (1) to provide general inventory procedures which local planning agencies can use and modify as a means of identifying and protecting important natural and cultural values, and (2) to identify and plan for areas of critical environmental concern to the state as a step in the formulation of a state planning process.

Objectives

1. To select a pilot study area that could be considered "critical" in terms of environmental resources and impending development. 2. To determine which natural qualities enhance or constrain various land uses. 3. To acquire a natural resource data base sufficient to illustrate the inventory method by determining the usability of existing data and testing the use of alternative data sources such as field work, remote sensing and professional consultants. 4. To interpret and communicate complex data to the public and decision makers in a form and at a scale usable for planning. 5. To suggest a means of analysis so that information gathered and interpreted accurately portrays physical interrelationships as a primary basis for land capabilities.

Assumptions

1. Land should be used within an understanding of natural processes. 2. Maximum public participation will contribute to the thoroughness and acceptability of the natural and cultural resource inventory. 3. Certain procedures of data acquisition and resource analysis are adaptable to any region of Montana despite the wide diversity of natural and social conditions throughout the state. 4. State and local planning agencies with limited technical and financial capabilities can conduct useful natural resource inventories if they are committed and willing to modify the generalized approach of this report to fit local conditions.

Study Area Viewed from the Swan Range – 1905

Valley Floor Seen from McCaffery Hill – 1972

Area Description

The demonstration area comprises approximately 15,040 acres of state and private land in Flathead County and lies in the northern end of the Swan Valley between the Swan Range to the east and the northern extent of the Mission Mountains to the west. As shown by the locator map, Flathead Lake is a short distance to the southwest, Kalispell is about 18 miles to the northwest, and Glacier Park is about 40 miles northeast of the study area. Roads and section lines outline the study area rather than topographic features, because it was felt that cultural boundaries would more closely approximate the realities of an actual planning situation.

After the land was cleared in the early 1900's, the predominant use was agriculture, but recently permanent and recreation homesites are changing the land use pattern. Although no nationally recognized historical landmarks exist in the area, there are several old Indian hunting trails and encampments.

The relief varies from 3,000 feet above mean sea level about one mile west of Peterson Lake to 3,920 feet in the Swan Range foothills.

The Swan River, flowing north from Swan Lake, meanders across the valley floor and empties into Flathead Lake. Surface streams that drain into Swan River within the study area include Mud, Wolf, Bear, and Peterson Creeks. Other surface streams are Echo Creek, which empties into Echo Lake, and Noisy, Rocky, Deer and Birch Creeks, all of which flow into Mud Lake. Lakes created by melting icebergs are scattered from near Bigfork up the eastern Flathead Valley to Columbia Falls. Locally this area is called the "Pothole Lakes Region."

The area has a cool climate with an average annual precipitation of 21 inches. The combination of geologic materials, relief, climate, vegetation and wildlife has resulted over time in a wide variety of soils. The complex interaction of hydrology, climate, soils, slope, aspect and elevation is responsible for ponderosa pine and Douglas fir predominating in the western half of the area and more moisture-loving species, including grand fir, birch and western red cedar, in the eastern half. Spruce, quaking aspen, birch and cottonwood grow on moist sites along river and stream courses.

The present landscape of the Bigfork study area is the sum of its natural history, described later, as well as man's long and continued use of the land.

NATURAL RESOURCE INVENTORIES

For the purposes of this study, natural resource inventory is broadly defined as the summation of all steps necessary to present natural resource information in a form usable for planning. Generally, these steps include the gathering of data, the interpretation of the data for planning, the analysis of the data to determine resource interrelationships, and the communication of that data to the public in a readily understandable form. The inventory should proceed from a general awareness of the physical characteristics of a planning unit to more detailed studies of each resource.

Before initiating the field inventory, maps of the study area should be acquired. Small scale maps, such as 1:250,000 Army Map Service maps, are useful for an overview. More detailed topographic maps at scales of 1:24,000 or 1:62,500 may be obtained from the U. S. Geological Survey or local map distribution points. Inexpensive blueline maps made from the topographic map are excellent for general field purposes.

Need for Inventories

It is a fact that most of the natural resource features described in the following pages have not been inventoried on an area-by-area basis. Without accurate inventories that locate, identify and describe important natural resources, it is questionable whether development can be imposed without costly consequences for people and the land. Even mitigation of adverse developmental impact is a difficult task without adequate information upon which to base land use decisions.

The challenge is to initiate inventories of at least the following critical features for planning jurisdictions within Montana:

1. present land use patterns
2. geology - hazard areas
3. climate
4. surface - subsurface hydrology
5. soils
6. vegetation
7. natural - cultural diversity

Although considerable physical land and water information exists, it is in a fragmented form, scattered among a wide spectrum of public and private organizations. The data are difficult to locate and often unavailable in a form meaningful to the potential user.

The level of detail applied in this study, which should provide a better understanding of small, high priority areas, should also be adaptable to county, regional or state-level inventories.

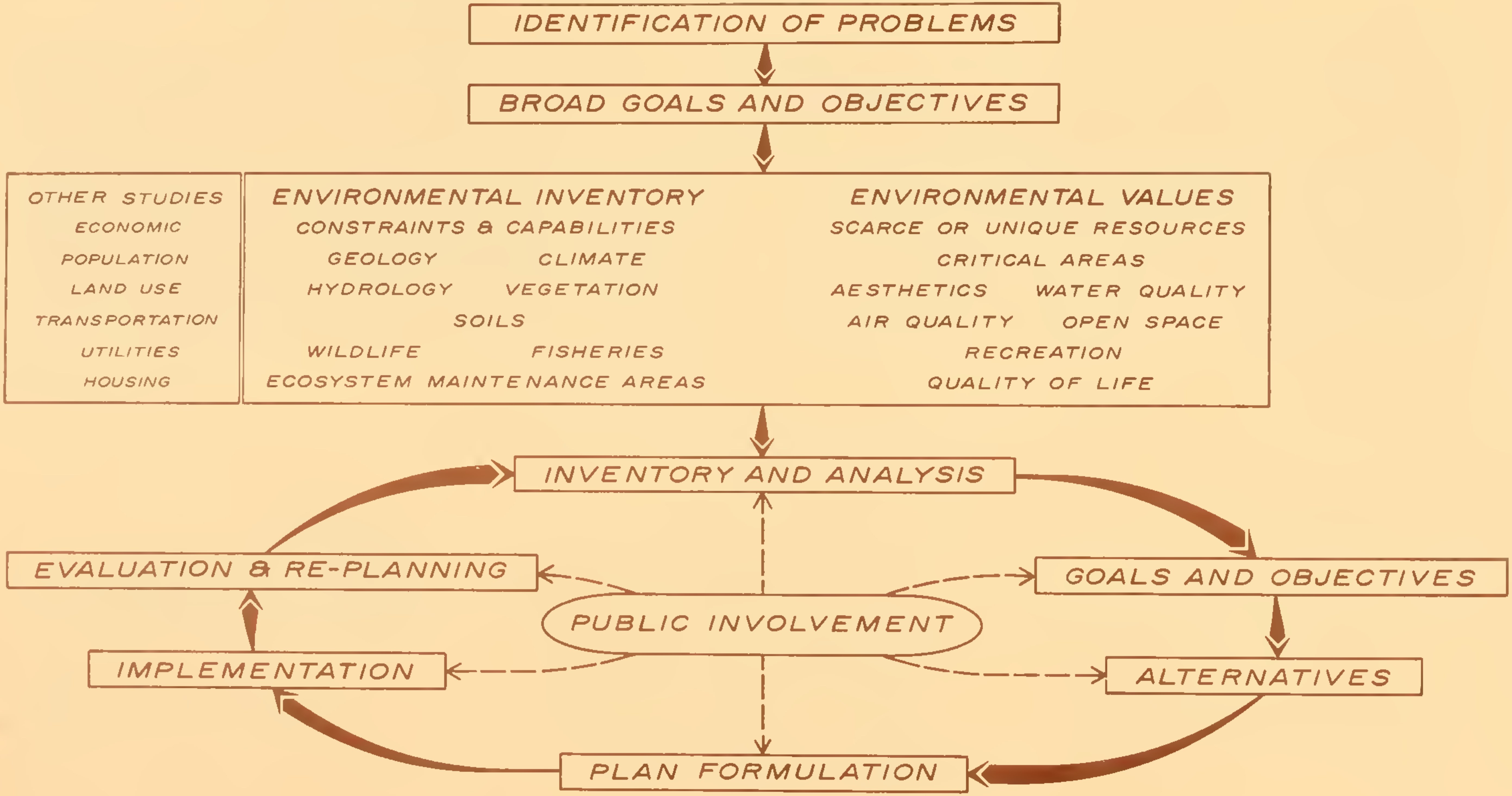
Such inventories can provide part of the informational basis to determine the point at which man can exist in harmony with his environment without unreasonable sacrifices to human life, property and the amenities that provide for a meaningful existence.

Natural resource inventories can be used to involve the public in the planning process, to select planning priorities, to communicate complex information in an effective way to decision-makers, and ultimately to form the rationale for growth policies.

Role of Inventories

The inventory phase is the first major step in the comprehensive planning process. Inventories generate the data necessary for specification of planning objectives. Natural resource inventories, along with other essential information, are the foundation of the land use plan.

PLANNING PROCESS



Preliminary Steps

Public policy to formulate a comprehensive plan will have been determined before the inventory is begun.

By carefully listening to their constituency, staff planners and decision-makers can identify planning problems such as the difficulty of providing adequate local services to widely scattered subdivisions or the impact of development in environmentally sensitive areas. This awareness of land use problems will help point the way toward such broad objectives as preservation of open space in a given area.

With a policy framework in mind, the need for a natural resource inventory should be evident. As a logical extension and based upon the initial identification of problems and general planning goals, the next important step is determining the specific objectives of the environmental inventory. By knowing beforehand the type of information that the inventory should produce, a number of questions including kind and detail of information can be answered and costly mistakes prevented.

Planners should clearly understand how the natural resource inventory fits into the broader planning process before the inventory is begun (see planning process diagram on Page 8).

With these factors in mind, the area to be inventoried may then be selected, if not already determined by the legal jurisdiction of the planning agency. Selection criteria can be derived from broad county or regional inventories which provide an indication of critical areas. The setting of priorities of areas to be inventoried should be based on rate of development, location of physical hazard areas, and important natural and social values.

Before acquiring physical land and water information for the planning unit, it is helpful to spend enough time in the area to appreciate dominant natural and cultural values. For example, by initially obtaining a "feel" for the Bigfork study area, the crucial importance of water in relation to other resources was recognized.

In these early planning stages every effort should be made to obtain active representation of a wide range of community groups. The exclusion of any group may result in an unrealistic and ultimately unenforceable plan.

Data Acquisition

The natural resource inventory should begin with a complete survey of existing information to avoid unnecessary expenditures of time, effort and money.

Many people simply do not know where to go for natural resource data; others are often unsure of which data characteristics are relevant to planning. If the first two obstacles are cleared, the data must then be put in a usable form for public information and land use decision-making.

If the objectives of the inventory are adequately determined, the task of data acquisition can be greatly simplified. Individual agencies, such as those listed in the following table, are the key to existing information, and knowing the source for general categories of natural resource information is important.

It is crucial to ask agency personnel the right questions. The potential supplier of information must understand the purposes of the resource inventory if he is to furnish that data which will be relevant to the potential user. An indication of the usability of data can be obtained by comparing the resource agency's objectives in generating the information with the objectives of the inventory. If these objectives are widely separated in terms of application and detail of the information, considerable interpretation may be needed to translate the data for planning purposes.

While the agency's staff and funding limitations may preclude interpretative assistance, the agency may be able to assist to the extent of identifying those data characteristics that are useful for purposes of the inventory.

A thorough familiarization with all relevant existing information should point to gaps in data. As the information needs become known, the value of additional data acquisition techniques, including the use of consultants, field work and special order aerial photography may then be assessed. These procedures will be discussed under each resource section of this report.

A partial listing of potential data suppliers appears on Pages 10 and 11. This table, which contains a broad indication of the data-supplying capability of public and private organizations in Montana, is intended to provide only a general starting point for the gathering of more detailed information. Although the table is incomplete, it is evident that important physical land information is dispersed among many federal, state, regional, local, and private organizations. There are additional information sources in each county which should be consulted. Although not listed in the table, the various departments and research arms of the universities are excellent sources of information and assistance.

Statewide data coverage (column 6) does not necessarily mean that information exists for the entire state, but merely that the data isn't confined to a particular region of Montana. In addition, "no charge" for data generally applies only to small requests and does not include necessary duplication costs. Column 9 refers to personnel within various disciplines able to interpret data for planning purposes.

DATA SOURCES

1 FEDERAL Name	2 Data Types	3 Data Form	4 Map Scales	5 Data Location	6 Data Coverage	7 Ownership Classes	8 Cost For Public Agency	9 Interpretive Assistance
Soil Conservation Service	S,C,C,W_S,W_C, V,W,L	P,I,T,O,B,A	None	State and Local	Statewide	Private & Some State	None	S,C,W_S,W_C,V
Agricultural Stabilization & Conservation Service		Aerial Photography	1:20,000					
Forest Service 1 Administrative	S,G,T,W_S,W_C, V,W,L,E	UP,I,T,O,B	2"/mile	Regional & Forest Offices	Nat. Forests throughout State	National Forest	None	Varies with forest
2 Research Intermountain Forest & Range Experiment Station	V	P,UP,T,C,		All levels	Statewide	Public & Some Private	None	Forest Resources
Economic Research Service	S,A	P,UP,N,C		Regional Offices	Statewide	Private & Some State	None	S
Geological Survey	C,W_S,W_C,W_Q	P,UP,T,B,C	1:24,000 1:250,000	National, Regional, State	Statewide	All Classes	None	C,W_S,W_C,W_Q,A
Bureau of Land Management	V,T	UP,I,T,O, B,A	½"/mile 1"/mile	State, Local Offices	Statewide	Mostly Public Domain & Intermingled State & Private	None	V,W,W_C,W_S,R, G,A
Fish & Wildlife Service	W,F	P		All Levels	Statewide	Federal Refuges	None	W,F
Bureau of Outdoor Recreation	Outdoor Recreation	P,UP		National, Regional Offices	Statewide	Primarily State & Fed	Charge for Published Reports	R
Bureau of Mines	M	P,T,B,C	1"/20' 50', 100'	Regional Offices	Statewide	None	None	M
Bureau of Reclamation	S,G,T,W_S	P,UP,I,T, B,A	1:24,000	Regional Offices	Specific Project Areas	State & Private	None	S,G,W_S,W_C, W_Q
Bonneville Power Administration	S,G,C,W_S, V,W	UP,N,T,A	1:62,500 1:250,000	Regional & Local	West of Divide	Public	None	G,W_S,V,W,L
Environmental Protection Agency	W_Q,A_Q	P,UP,N,C		Regional Office	Statewide	All Classes	None	W_Q,A_Q
National Weather Service	C	P,T,B,C		National & Local Office	Statewide	All Classes	None	
Army Crops of Engineers	S,G,W_Q,F	P,UP,A		Regional Offices	Statewide	All Classes	None	Flood Plain Management
Pacific Northwest River Basins Commission	S,G,C,T,W_S, W_C,W,W_Q,F	P,T,B,O	Region: 1:1,500,000 Subregion 1:500,000	Regional Office	West of Continental Divide	Federal, State, & Some Private	Charge for Some Reports	G,H

1 STATE Name	2 Data Types	3 Data Form	4 Map Scales	5 Data Location	6 Data Coverage	7 Ownership Classes	8 Cost For Public Agency	9 Interpretive Assistance
Department of Natural Resources & Conservation	S,G,W_S,W_G,V	P,UP,N,T, O,C,B,A	Timber Maps: 1"/Mile County Maps: 1½"/Mile Aerial Photos: 4"/Mile Township Maps: 2"/Mile	State & Local Office	Statewide	State & Private	None	S,G,W_S,W_G,V
Department of State Lands	V,L	P,UP,N,T,B		State Office	Statewide	State	None	V,G
Department of Health & Environmental Sciences	C,W_Q,A_Q	P,UP,N,T,C		State Office	Statewide	All Classes	None	W_Q,A_Q
Department of Fish & Game	W,F,	P,UP,N		Regional Office	Statewide	All Classes	None	W,F
Bureau of Mines & Geology	G,I,W_G,W_Q	P,UP,N,I, T,B,A			Statewide	All Classes	None	W_Q,M
Department of Highways	S,G,T,W_G	UP,N,T,R,A	1"/80' 100', 200', 400', or 1 Mile	State Office	Statewide	State, Some Private	None	L,V,G
Environmental Quality Council	All Types (Secondary)	UP,N		State Office	Statewide	Primarily State	None	G,W,W_Q
PRIVATE								
Regional Planning Assoc. of W. Mont	S,G,C,T,W_S, W_G,V,M,L,W_Q,F	P,UP,N,I,T, O,B	1:250,000	Regional Missoula	West of Divide	All Classes	None	General
Burlington Northern	G,T,V,M	UP,N,T,O,B, A,C	2"/Mile 1"/1,000'	Regional & Local Offices	Mainly W of Divide	Private	None	V,G,S,A
U. S. Plywood	S,C,T,V	P,UP,I,T, A,C	4"/1 Mile 1"/1 Mile	State and Local Offices	West of the Divide	Private	None	S,V
St Regis Paper Co	V	UP,N,T,B	4"/1 Mile	Local Offices	Lincoln Co.	Private	None	V
Tree Farmers, Inc.	V,T	UP,B,A		State and Local Offices	West of the Divide	Private	None	V
Anaconda Company	S,G,W_Q,A_Q	UP,B,A		State and Local Offices	West of the Divide	Private and Nat Forest	None	G,W_Q,A_Q
Montana Power Co.	G,W_S,W_G,A_Q	UP,T,B		State and Local Offices	Statewide	Private	None	G,W_S,W_G
Pacific Power & Light	G,W_Q,A_Q,F	UP,N,O,B,A		Corporate Headquarters	Southeastern Montana	Private	None	C,G,M,W,F

SYMBOLS Columns 2 and 9: S-soils, G-geology, C-climate, T-topography, M-minerals, W_S-surface, W_G-ground water, W_Q-water quality, W-wildlife, F-fisheries, V-vegetation, L-landscape, R-recreation, A_Q-quality

Column 3: P-published reports, UP-unpublished data, N-narrative form, B-basic maps, I-interpretive maps, O-overlays, A-aerial photography, T-tabular, C-computer.

INVENTORY METHODS

Each of the following resource sections is comprised of two general parts: the method of acquiring and using resource data for land use planning, and a description of the study area presented to illustrate the method. Inventory procedures are the sum of the photography, maps, tables, and narratives of each section.

OWNERSHIP

An ownership search should precede the field investigation and resource inventory for it is ownership — and the economic considerations that accompany ownership — that largely determine how land is used.

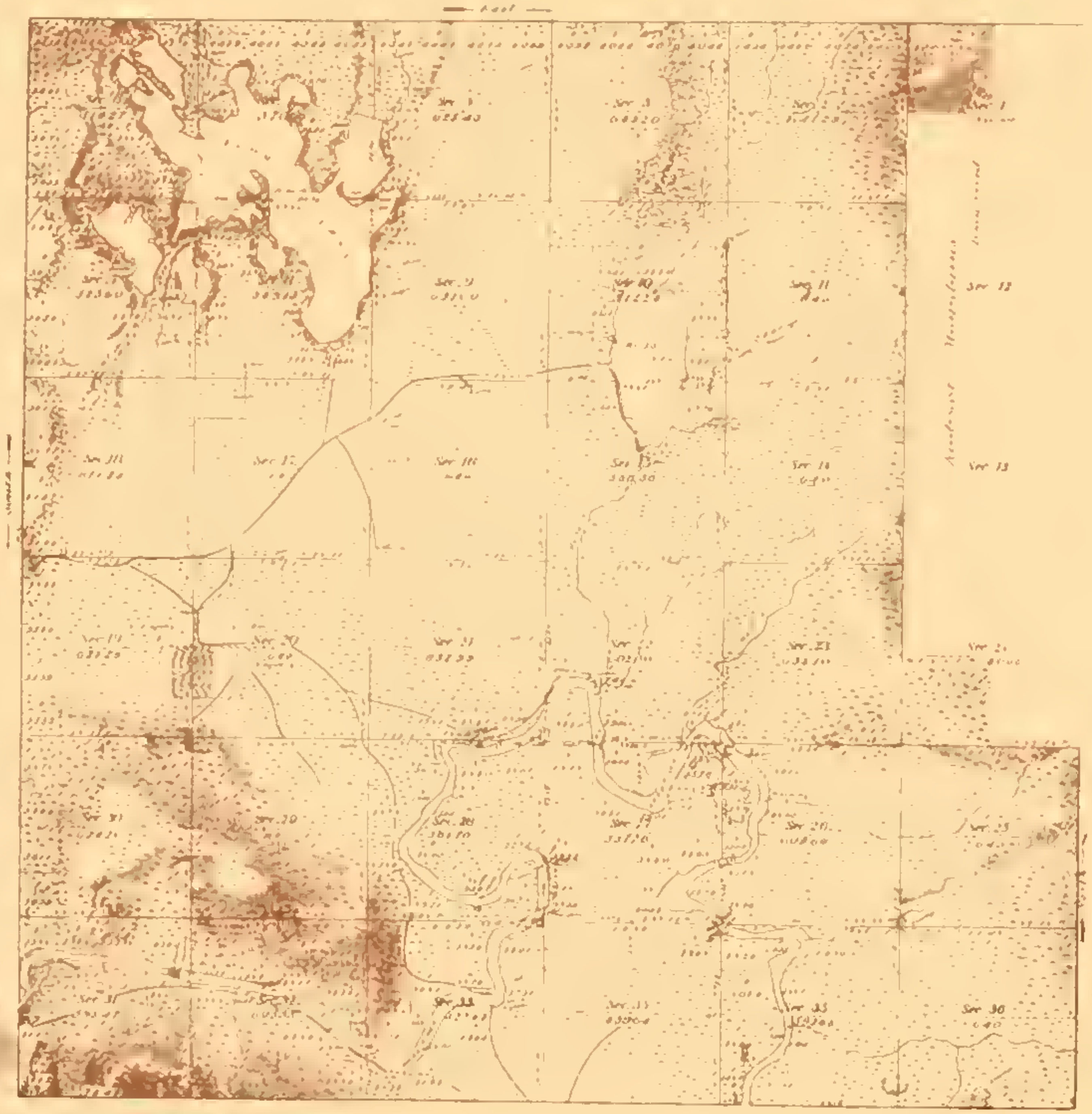
Considerable time was spent in locating the owners of record within the study area in order to gain permission to enter private property. The effort to locate owners and explain the inventory objectives will pay dividends in terms of better cooperation and valuable insight into local conditions.

Method

The courthouse in each Montana county is the principal source of ownership information. With prior knowledge of the townships and sections in the planning unit, the township plat books in the county assessor's office should be examined. Section maps containing property lines were adequate for the purposes of this report. If an updated section map is not available from the land classification office, the tract locations may be acquired from the latest map in the plat book.

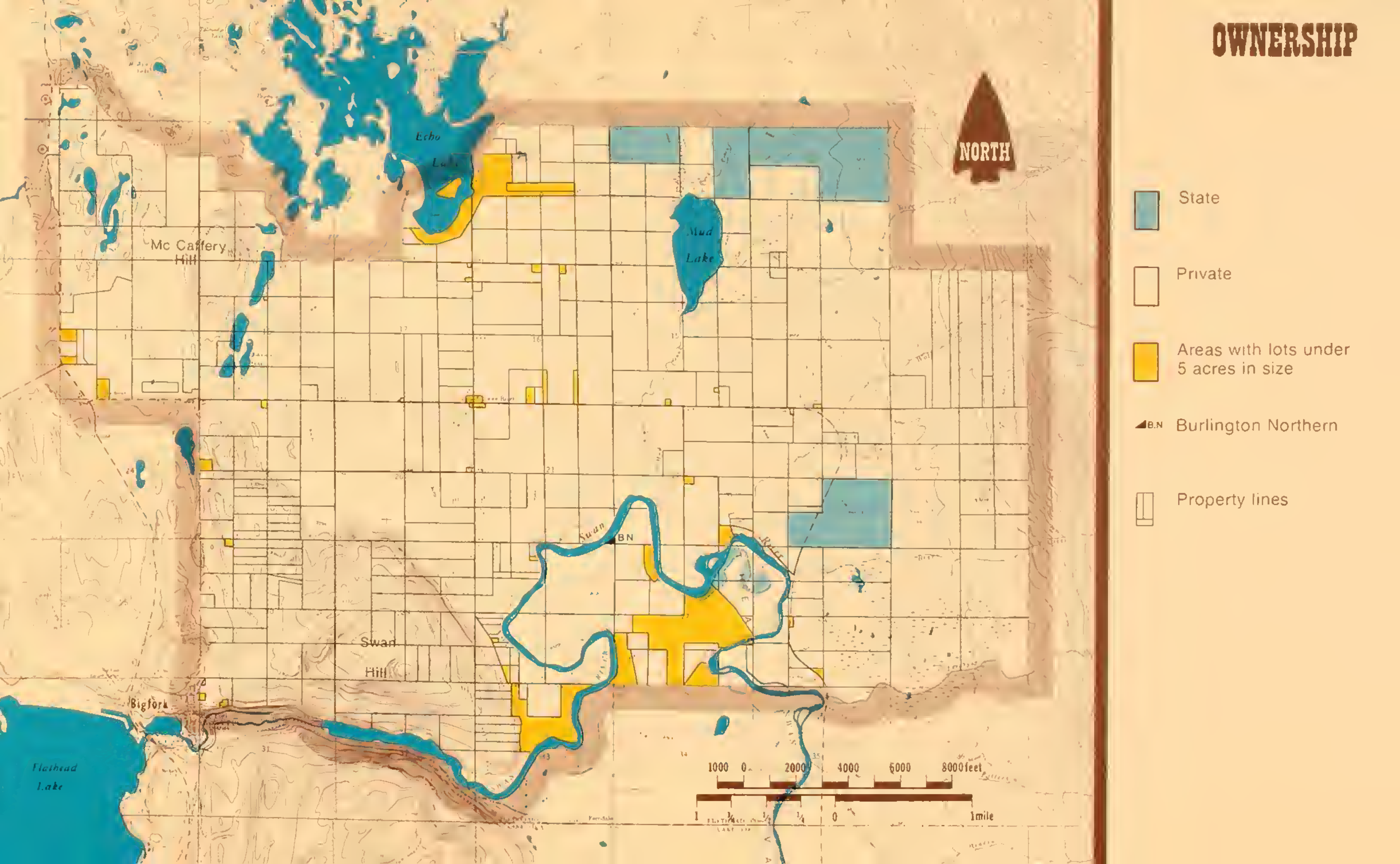
Another possible source of ownership data is the forest fire protection assessment rolls. The rolls for all counties in Western Montana and for some counties east of the Continental Divide are located at the various State Forestry Division Offices. Ownership is listed alphabetically for each section on computer printouts. However, subdivisons and tract locations are not indicated.

Time limitations during the field season prevented a determination of subsurface ownership. Although such knowledge was not particularly significant in this study area, the separation of surface and subsurface rights is a land use determinant in many parts of Montana.



Property Boundaries – 1893

OWNERSHIP


NORTH
State
Private
Areas with lots under 5 acres in size
B.N Burlington Northern
Property lines
Echo Lake
Mud Lake
Mc Caffery Hill
Swan Hill
Swan River
BN
Bigfork
Flathead Lake
1000 0 2000 4000 6000 8000 feet
1 ½ ¼ 0 1 mile

LAND USE

Knowledge of the type, distribution and intensity of land uses is essential to evaluate the impacts of those uses in any given planning area. Land use maps show present commitments to particular land use patterns. Information on current uses combined with growth projections may indicate possible land use changes.

Method

The land use classification system applied in this study is based primarily on remote sensing techniques. Land cover, which can be determined directly from such techniques, is the basis for identifying first level land uses (e.g. urban) and second levels (e.g. residential).

Many activities are directly related to the type of land cover. The existence of planted wheat indicates that farming is the land-using activity on a particular tract. Other activities such as recreation cannot be inferred from land cover and therefore cannot be determined solely from remote sensing. Complementary techniques are thus needed to identify recreation as a land-using activity.

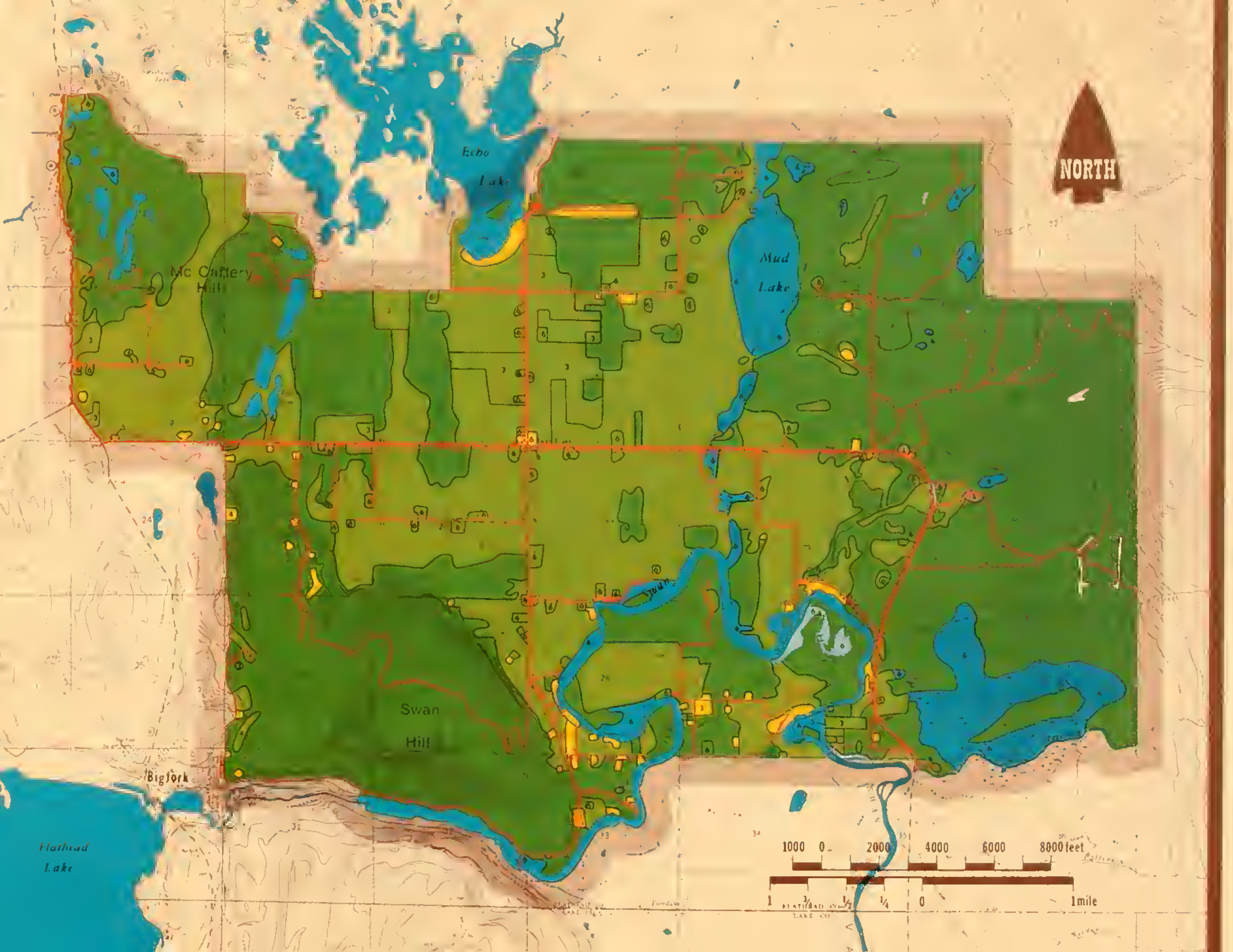
Although the land uses were derived primarily from remote sensor data (see map page 15), further information beyond remote sensing capability was obtained by transferring the data from overlays to a topographic base map. Questionable uses were confirmed with ground level land use information obtained during the field inventory. Much useful information about past and present land use was gathered from local residents. Such knowledge is useful for other resource inventory needs. For example, existing vegetation is often a result of land use. In addition, the soil and water conservation needs inventories for Montana and each county, produced by various federal and state agencies, provide a good starting point for basic land use information.

The placement of boundaries for each land use class may be difficult, since clearly defined classes are rare. The question of the minimal area which must be devoted to a given land use before it is so classified must also be addressed. These questions may be further complicated by heterogeneous mixtures of equally significant land uses within one area.

There is no perfect classification system since any system must satisfy the needs of the particular user. The approach used in this study, which has been modified from the national land use classification system proposed by the U. S. Geological Survey, is not suggested as a standardized means of classifying land use throughout Montana. The development of a uniform statewide system will require use, revision and improvement.

LAND USE CLASSIFICATION SYSTEM

LEVEL I		LEVEL II
1.0 Urban	1.1	residential
	1.2	commercial and services
	1.3	industrial
	1.4	water, sewage and solid waste facilities
	1.5	public and institutional other than above
	1.6	recreation facilities
	1.7	other open land
2.0 Scattered, Built up	2.1	residential
	2.2	commercial and services
	2.3	industrial
	2.4	water, sewage, and solid waste facilities
	2.5	public and institutional
	2.6	recreation facilities
3.0 Agricultural	3.1	cropland and pasture (irrigated)
	3.2	cropland and pasture (dryland)
	3.3	tree plantations
	3.4	orchards, groves, bush fruits and horticultural areas
	3.5	feeding operations
	3.6	farmstead
	3.7	recreation facilities
4.0 Rangeland	4.1	grass
	4.2	grass predominant
	4.3	brush
	4.4	brush predominant
	4.5	savannah
5.0 Forestland	5.1	deciduous
	5.2	conifer
	5.3	mixed
	5.4	timber management areas
	5.5	recreation facilities
6.0 Water Areas	6.1	natural major streams (rivers)
	6.2	natural minor streams (creeks)
	6.3	intermittent streams
	6.4	natural lakes
	6.5	man-made water facilities
	6.6	marshes
	6.7	flood plains
	6.8	recreation facilities
7.0 Barren Land (non-vegetated)	7.1	talus slopes
	7.2	bare exposed rock
	7.3	clay hills - badlands
	7.4	alkali flats
	7.5	man-made saline areas
8.0 Mineral and Energy Production Areas	8.1	stone, gravel, sand extraction or storage
	8.2	open pit mineral extraction
	8.3	tailings, extensive
	8.4	underground mining, working access areas
	8.5	electric generation facilities
	8.6	gas wells
	8.7	oil wells
9.0 Transportation, Communication and Utilities Corridors	9.1	major highways (Interstate)
	9.2	primary highways
	9.3	secondary highways
	9.4	unpaved double-lane roads
	9.5	unpaved single-lane roads
	9.6	railroad corridors and facilities
	9.7	airports
	9.8	communication corridors, sites
	9.9	major transmission corridors
	9.10	minor transmission corridors
	9.11	gas lines, pipelines



LAND USE

🟧 Urban
Bigfork

🟨 Scattered Built Up
class 2.1 unless otherwise indicated

🟩 Agricultural
class 3 2 unless otherwise indicated

🟩 Forestland

🟦 Water Areas
streams or lakes unless otherwise indicated

☐ Barren Land

🟫 Mineral and Energy Production Areas

Transportation, Communication and Utilities Corridors

— primary highway

— unpaved double-lane road

- - minor transmission lines

HISTORIC VALUES

Much of the uniqueness and diversity of any area is due to its history. Identification of historical values is the first step toward their preservation. It is important to get a historical perspective of the planning unit so as to give meaning to individual sites. The value of old buildings and other features as irreplaceable cultural values should be assessed before allowing development that may inadvertently destroy important remnants of our historical heritage.

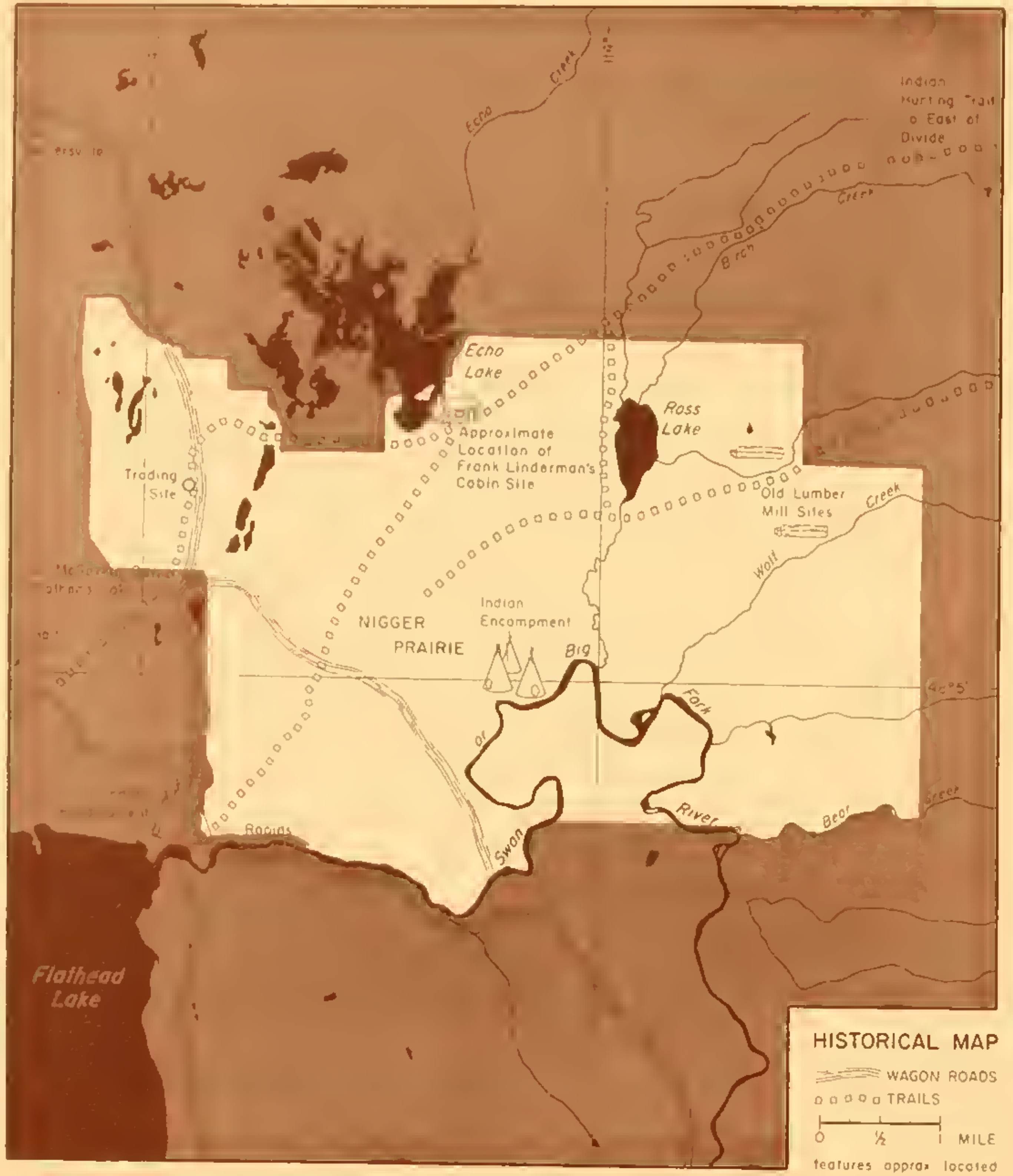
Method

Interest in and study of local or regional history has flourished in Montana in the past several years, and material is available on most areas of the state. Local and county libraries often contain extensive information on their respective locales. Specialized books, pamphlets, reminiscences and clipping files reflect the history and development of these regions and counties. County and city governments also maintain necessary records which are often valuable sources to the regional or area historian.

Research can also be undertaken at the Montana Historical Society Library in Helena, which is charged by statute with the preservation of Montana's past. In this library are most of the materials published on all areas of Montana. In addition, the Society holds about 95% of all the newspapers published in the state including those which appeared when Montana was a territory. This collection alone is a valuable reference tool for the researcher seeking information on a locality. To facilitate area or regional historical research, the Society's library is in the process of preparing a guide to materials available on local history. Structured by county, this index will reflect all the library's holdings pertinent to the study of county or regional history.

A general search for historical values should include a study of the Montana Historic Preservation Plan, published by the Montana Fish and Game Commission, which contains a comprehensive survey of historical sites. However, local historical values are often significant but only locally known and do not normally appear on a general listing.

Other sources of historical data on an area include county historical societies, local historical groups and resident historians, amateur or professional. For example, the information shown on the accompanying history map was obtained from local residents. Not to be discounted is the growing field of oral history, and the memories of early residents are many times the only source of certain information. This oral data, supported by more standard sources, can many times best reflect the past.



Area History

With the gradual melting of the ice of the Pleistocene glacial period, a wide variety of flora and fauna invaded the area. When the flora and fauna had developed sufficiently to meet human food needs, which may have been 3,000 to 5,000 years ago, aboriginal inhabitants appeared, migrating from areas to the south and west which had escaped glaciation. Very little is known of the exact type of Indian who first arrived.

When the white man came, this northwestern Montana area was populated by the Upper Kootenai tribe with the Kalispell to the west, the Salish to the south and the Blackfeet to the east. Undoubtedly the territories of these tribes periodically overlapped.

The arrival of relatively large numbers of white men in the 1880's signaled the end of the Indian's traditional way of life. Indian-white relations in the study area were peaceful except for one or two minor skirmishes.

EARLY SETTLERS

The compartively late arrival of white men to intermountain northwestern Montana was due, not to mountain barriers, but to the extreme hostility of the feared Blackfeet Indians to the east. In 1809 David Thompson of the Northwest Trading Co. was the first white man to view this region.

The discovery of gold in Montana in 1858 brought miners to the west central portion of the state in the following decade, and the study area is thought to have been visited by prospectors in the late 1860's and 1870's.

With the completion of the Northern Pacific Railroad through western Montana in 1882, the influx of settlers began. The first white man to live in the study area was Frank Linderman, later a well known author and friend of the Indians.

The names and numbers of settlers were unrecorded during the next decade, but around 30 home and cabin sites mostly occupied by retired trappers, were recorded in an 1893 survey.

BEGINNINGS OF AGRICULTURE

Many of the early residents were part-time farmers who spent considerable time hunting, fishing and trapping. After 1890 the true farmers began to emerge and gradually bought out the original settlers or homesteaded land of their own.

Clearing the forest was slow and arduous work. Crops consisted mainly of spring wheat, oats and barley. General farming was somewhat limited because of short growing seasons and frequent frosts which might occur even during the summer months. Later, because of frost danger, cabbage and cool weather root crops such as potatoes, carrots and rutabagas were grown in large quantities and stored in root cellars. The earliest white settlers used some trees for buildings, fences, and fuel, and beyond this trees were burned for land clearing purposes. Due to extensive logging operations and improved machinery, eventually more land was cleared and put into cultivation and improved pasture.

EARLY LOGGING

With increasing settlement more finished lumber was in demand. The first sawmill in Flathead Valley was a waterpowered mill built in 1884 near Foy's Lake, and shortly thereafter several small mills began production. The J. O'Brian Lumber Co. constructed a mill at Somers with a yearly capacity of 40 million board feet. Logs were transported on the Flathead and Swan Rivers and towed across Flathead Lake to Somers.

Montana's lumber industry of this period was enhanced tremendously by the coming of the transcontinental railroads, the boom in the silver and copper mining industries, and the consequent population influx. The greatest impetus to the local lumbering industry was the Great Northern Railroad, which was constructed through the northern Flathead Valley in 1892.

In the study area the most extensive logging was done between 1905 and 1910. The logs were skidded to the Swan River bank during the winter and floated down during spring and early summer high water.

OTHER INDUSTRIES

Except for lumbering and sawmill activity, the only local industry recorded was a small cheese factory located ½ mile north of the present Echo Lake store.

A hydroelectric power plant was constructed at Bigfork just outside the study area in 1901. In 1907 this was sold to Northern Idaho and Montana Power Co., and a low concrete dam was constructed across the Swan River above the rapids, forming a small lake.

The Holt-Swan Ranger District, with a ranger station at the head of Swan Lake, was established in 1899, and the Echo Ranger District was set up in 1910. Numerous fire trails, telephone lines and facilities such as fire lookouts were constructed. In 1910, a severe fire year, a destructive forest fire burned the mountain sides, leaving scars still visible to the east of the study area.

The historical land use activities of agriculture and logging continue today with increasing trends toward residential and recreational uses.

GEOLOGY

The most obvious need for geological information is for physical planning. Knowledge of geologic hazards is crucial to the proper design and location of transportation and utility facilities as well as foundations. This information is also needed for the safe development of waste disposal and water supply units.

Method

The U. S. Geological Survey (U.S.G.S.) and the Montana Bureau of Mines and Geology conduct research and publish geologic reports on certain areas in Montana. The reports and a list and index map of these publications may be found at the U.S.G.S. offices in Helena and Billings or at the Bureau office in Butte. Many of the reports are also available at local and university libraries.

Less detailed geological reports are published for most counties as part of the water resources surveys conducted by the Montana Department of Natural Resources and Conservation. Other miscellaneous sources of geologic information include water well logs and mining claims. Aerial and satellite photography are valuable tools for drawing or supplementing geologic maps.

Geologic studies provide substantial information, but interpretation of these data from any source require the services of a competent geologist. Consultants specializing in geology for land use planning are few, but their numbers are increasing.

The study of the geology in the Bigfork study area began in the summer of 1972, when a consultant conducted an environmental geology study. The procedures used were: (1) a data search for sources of published and unpublished materials; (2) interpretation of aerial photography; (3) assimilation and interpretation of all data; (4) field investigation to substantiate assumptions and complete data collection; (5) re-evaluation of the geology; (6) preparation of an interim report; (7) derivation of geology maps from infrared photography and field reconnaissance data; and (8) preparation of final report for publication.

The infrared aerial photos were especially valuable in the identification of springs and grass roots water tables by the red-pink shades of healthy vegetation on the photos. The stereoscopic coverage was useful in detecting changes in slope, which often reflect a change in rock type. Some landforms such as the alluvial fan were first seen on these photos and later verified by the soils maps.

The source of ground-water data shown on the geologic resources and hydrology maps was the ground-water appropriations on file with the Water Resources Division of the Department of Natural Resources and Conservation. Montana Bureau of Mines and Geology Bulletin 68 showed artesian pressure contours extending into the Swan Valley. These contour lines were correlated with the well record data.

Field work is an important phase of any geological study. However, because it is usually the most expensive inventory technique, field work should be minimized whenever possible by first analyzing all existing data. Field work should verify indefinite information and fill in missing facts.

Generally, the geological inventory for broad county level planning should include, at the minimum, gross features such as differentiation between bedrock and valley fill material, major landforms, geologic resources, principal aquifers and recharge areas, and geologic hazards. Visual observations of such features by a field geologist, rather than expensive geo-physical studies, are normally adequate for supplying this type of information.

The basic analytical unit of a geological study is the individual landform. The landscape can be segregated into recognizable landform units which reflect the differing processes by which they were developed. The most dynamic of these processes is erosion, followed closely by deposition and finally by seismic activities.

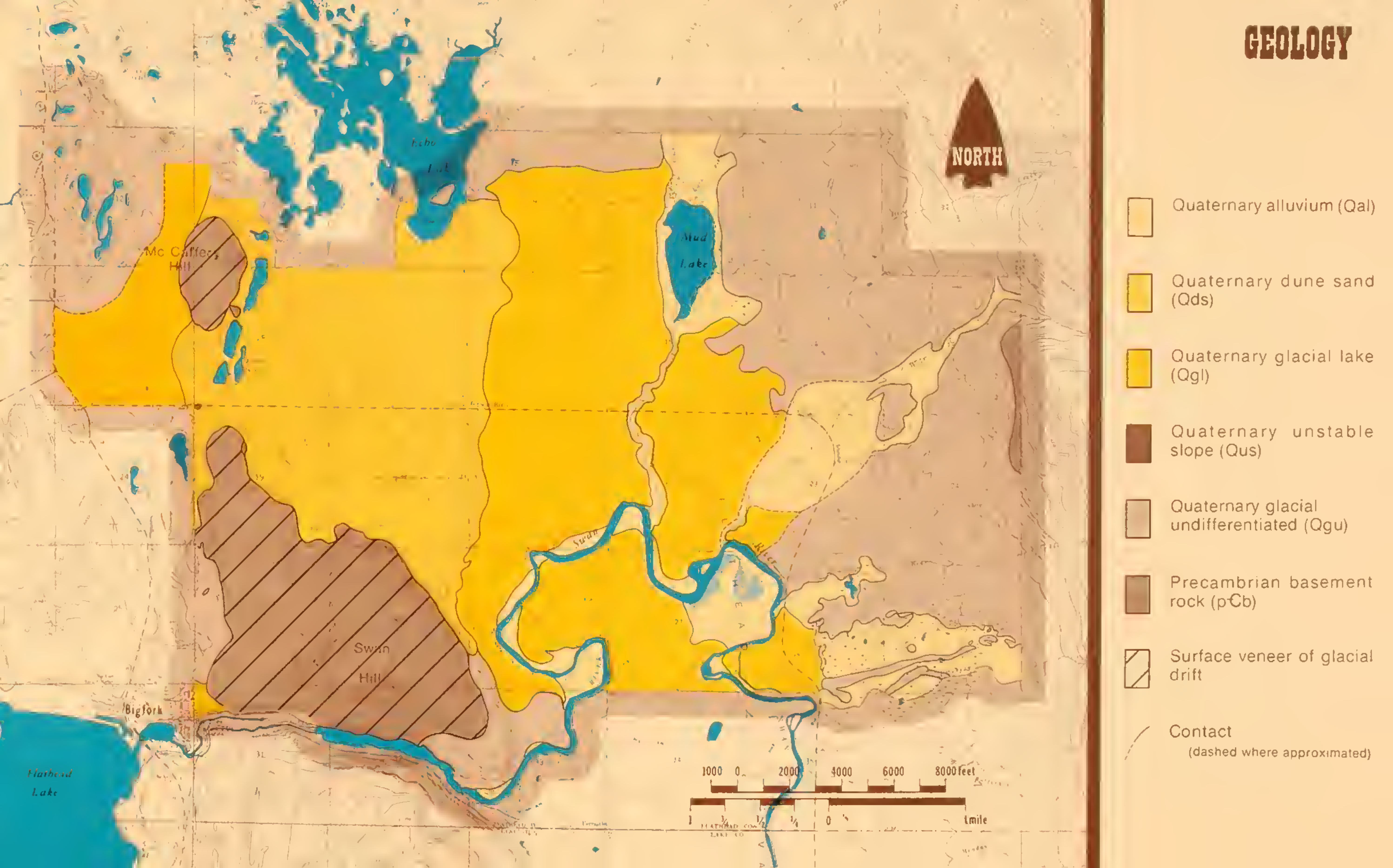
Area Geology

The Swan Valley occupies the long, narrow downfaulted trough between the Swan and Mission ranges. The Swan basin is typical of the Northern Rocky Mountain province, which is characterized by successive northwesterly trending mountain ranges and valleys. The mountain blocks are made up of extremely old, resistant pre-Cambrian marine sediments.

The geologic history of the region is largely unknown prior to about 5 to 10 million years ago, when forces deep in the earth began lifting these formations. Faulting and folding raised the entire Rocky Mountain province and also caused differential uplift of the mountain blocks over the valleys. The mountains continued to rise intermittently for millions of years. Since the first surface expression of the Swan Valley, rock debris has been eroded from the mountains into the valley, and the Swan trough has collected at least 4,000 to 5,000 feet of eroded material. The nature of this valley-fill deposit is only inferred below about 250 feet, but it is suspected that at greater depths the valley is filled with coarse, water bearing gravels.

About two million years ago, climatic changes brought on the increases in precipitation and colder temperatures which initiated the Ice Ages. During the Ice Ages there were three to five major glacial advances and retreats in northwestern Montana. The Flathead Lobe of the Cordilleran ice sheets moved down the Rocky Mountain Trench from Canada and converged with smaller alpine glaciers near Bigfork. The northwesterly flowing Swan Valley glacier merged with the huge, southerly moving Flathead glacier and was bent around the northern end of the Mission Range. As the Swan glacier overrode the mountains, it scoured curving valleys completely across the northern end of the range.

There is evidence that the climate was both drier and more humid at different times. The proof of a wetter climate is found in small, post-glacial unoccupied cirques in Glacier National Park, while documentation of arid conditions may be seen in the sand dunes of the study area.



GEOLOGY

NORTH
Echo Lake
Mud Lake
Mc Caffery Hill
Swan Hill
Bigfork
Flathead Lake
Swan River
1000 0 2000 4000 6000 8000 feet
1 ½ 0 1 mile
Quaternary alluvium (Qal)
Quaternary dune sand (Qds)
Quaternary glacial lake (Qgl)
Quaternary unstable slope (Qus)
Quaternary glacial undifferentiated (Qgu)
Precambrian basement rock (p€b)
Surface veneer of glacial drift
Contact (dashed where approximated)

Landforms

The developmental limitations of each major landform within the study area are listed in the adjacent table and shown on the accompanying map.

The Swan River flood plain, composed of silty clay loam soils, has evolved from the deposition of glacial Lake Missoula sediments and their subsequent erosion by the Swan River.

Flood Plain Landform

Although the valley floor is essentially flat and featureless, the western portion has some rolling hills of dune sand. The floor is composed of glacial drift overlain by as much as 50 feet of flat lying glacial lake silt. A definite drainage pattern is not evident except near the river.

An alluvial fan has been washed onto the valley floor by Wolf Creek, which eroded glacial drift from the foothills and deposited it on the flatter slope. Silty clay loam and stoney silt loam soils have developed on this deposit.

Valley Floor Landform

Kame and Kettle Landform

Swamps in the southeastern corner of the study area are formed by beaver-dammed creeks. These dams have built a stairway of lakes up the Swan Range foothills which in time become congested with sediment and plant life.

Kame and kettle landforms are unique to glaciated areas. A kame is a small steep hill of sand and gravel caused by meltwater from the glacier. A kettle is the impression caused by floating ice surrounded by sediment. When the ice melted, the adjacent material partially filled the hole. Shallow gravelly loam soils formed on this topography.

Foothill Landform

The material in the foothills is a mixture of boulders, gravel, sand, silt and clay, with clay predominating. The soil types are stoney silty loams.

McCaffery and Swan Hills, the northern extensions of the Mission Range, are bedrock islands covered with glacial drift and surrounded by the valley floor. Stoney, silty loam soils developed on these slopes.

LIMITATIONS BY LANDFORM

1. Flood Plain Landform
    a. grass roots water table
    b. periodic flooding
    c. stream channel changing
    d. susceptible to stream and ground-water pollution
    e. locally swampy
    f. high seismic risk

2. Valley Floor Landform
    a. poor surface drainage
    b. moderate seismic risk

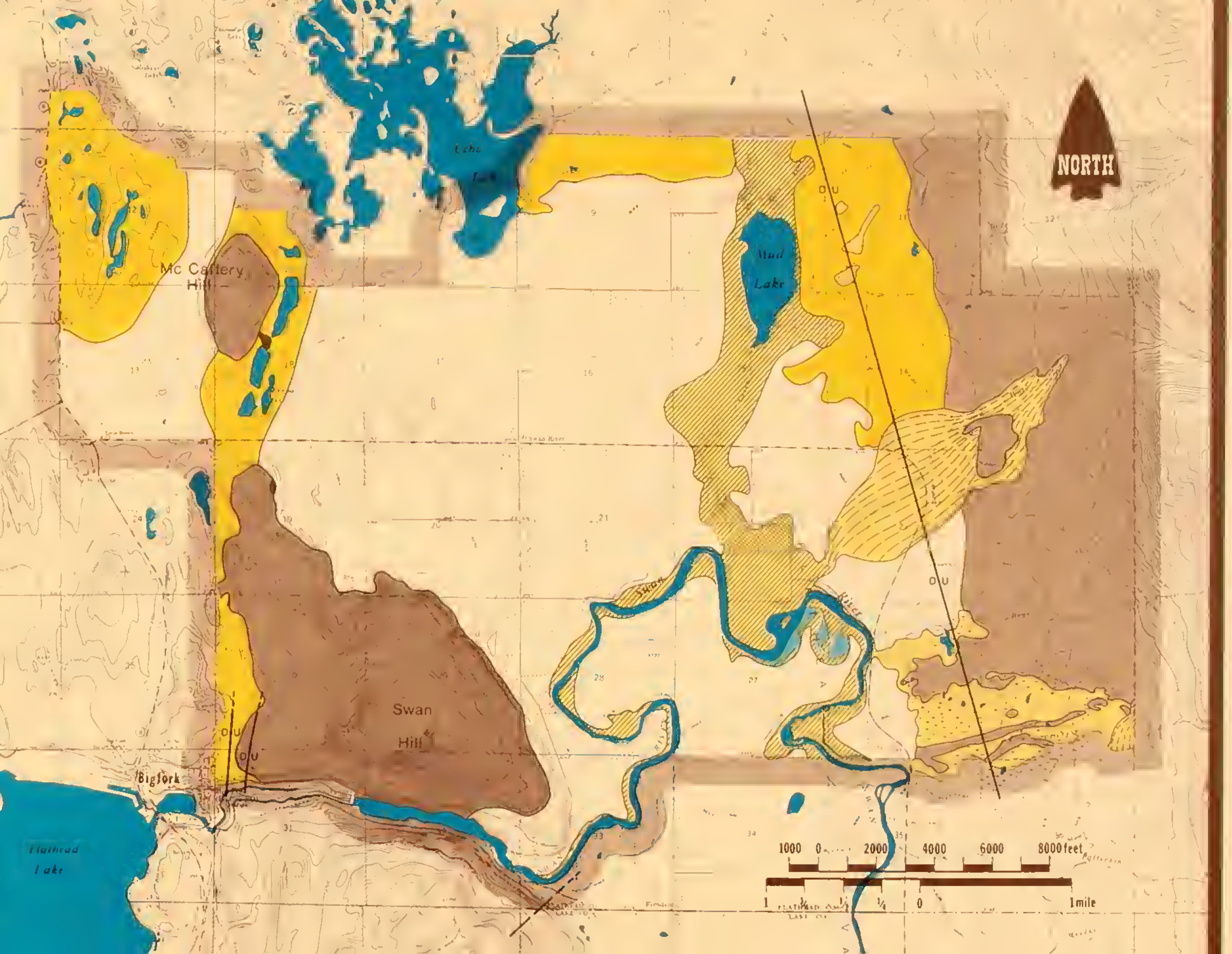
3. Alluvial Fan Landform
    a. seasonally high water table
    b. slope instability
    c. high seismic risk
    d. minor ground water recharge area

4. Swamp Landform
    a. poor surface drainage
    b. foundation settling
    c. high seismic risk
    d. perennially high water table

5. Kame and Kettle Landform
    a. susceptible to lake and ground-water pollution
    b. lake levels subject to great fluctuation
    c. slope instability
    d. high seismic risk

6. Swan Range Foothills Landform
    a. limited ground-water supply
    b. susceptible to erosion problems
    c. locally swampy
    d. small minor ground-water recharge areas
    e. low seismic risk

7. McCaffery and Swan Hills Landform
    a. limited water supply
    b. hard and deep water well drilling
    c. possible pollution of deep ground water
    d. low seismic risk



LANDFORMS

Limitations

- ☐ Valley floor
- ▨ Swamp
- ▨ Flood plain
- ▨ Alluvial fan
- ■ Kame & Kettle
- ■ Swan Range Foothills
- ■ McCaffery & Swan Hills
- ■ Talus & landslides
- D\U Geologic fault

LANDFORM LIMITATIONS

In areas where limitations exist, special precautions should be taken if man attempts permanent alterations.

The flood plain landform, which results from the deposition of sediment during floods, is prone to structural settling and water-related problems. Loose, uncompacted and often unstable flood deposited material shifts and settles from natural causes such as earthquake, or from human causes, such as slopes being cut at steep angles. Flood plain materials, friable and water-filled, may liquify into viscous fluid in which heavy objects sink and light objects float.

Difficult Excavation Indicated by Large Boulders

Water problems are the most severe of any environmental limitations in the flood plain. Excessively high water table, stream migration and periodic inundation are common. A high water table in the flood plain can be lowered by artificial drainage. However, where vegetation is dependent on a high water table, artificial reduction can produce undesirable side effects.

The floor of Swan Valley has comparatively few constraints to development. However, this landform is composed of unconsolidated glacial lake clays and silts, which slump easily if a slope has been over steepened or denuded of vegetation. The infrequently active Swan fault underlies the valley floor landform. Smaller faults dissecting the rock strata near Bigfork (see landform limitations map) have had slight movements, but no known damaging earthquakes have occurred in the study area. The nearest destructive shock was recorded in the Swan Valley at Condon.

The major constraints of the alluvial fan landform are foundation settling, slope instability and likelihood of earthquake damage. The alluvial fan also has a seasonally high water table. Fragile areas include springs in the lower reaches and a ground-water recharge area at the upper end. The water recharging the Wolf and Peterson Creek alluvial fans re-emerges in the beaver swamps.

The kame and kettle landform is especially susceptible to water quality degradation. When water-saturated, the steep slopes surrounding the kettles slump to a more stable angle, and the kame and kettle landform thus has a high risk potential. Low lying areas near Echo Lake may be subject to seiche flooding following a strong earthquake.

The foothills of the Swan Range are comprised of glacial till which generally yields small amounts of water to wells. Removing vegetal cover or steeply cutting slopes could result in erosion problems. The earthquake risk is lower than in the more water-saturated deposits in the low lying areas.

Development of McCaffery and Swan Hills is limited by availability of water. Because shallow wells may go dry in late summer, 150 to 300 feet wells are necessary. Although at great depth, the water table is easily contaminated by effluent from septic systems due to the vertical movement of water in the rock fractures to the deep ground water. Since Swan and McCaffery Hills have only a thin glacial till veneer over the solid rock, the earthquake damage risk is the lowest in the study area.

Geologic Resources

The Bigfork study area is in a part of Montana not known for mineral resources. The only mining in the area consists of three gravel and sand operations, two of which are occasionally active. Sand and gravel deposits are abundant in the northwestern portion of the area, but development of these resources is not economically feasible at present. Normally sand and gravel deposits should be located close to the use site, since transportation is a significant cost factor.

Large amounts of riprap and crushed rock are available for extraction in Swan and McCaffery Hills but are subject to the same constraints of high transportation cost and low value.

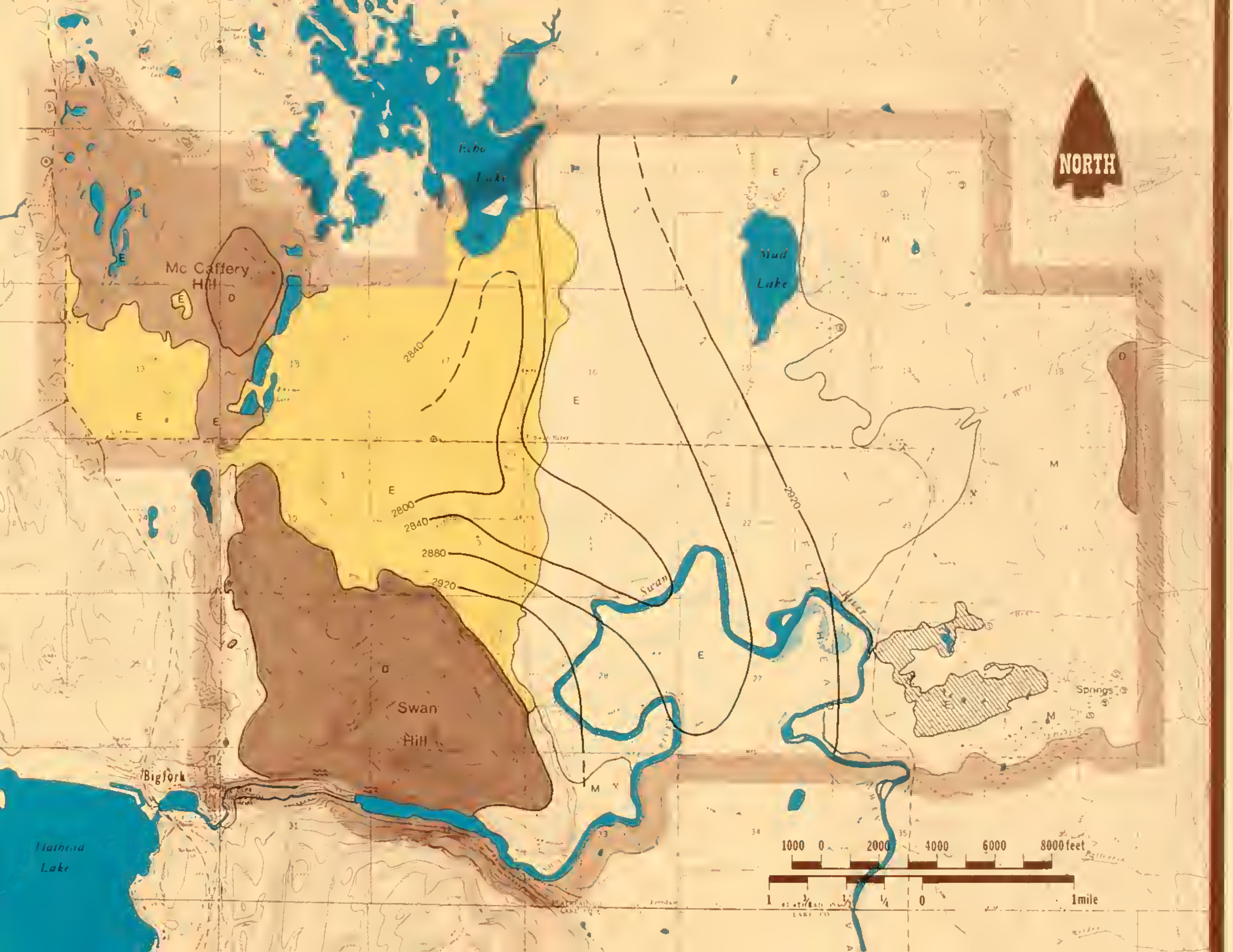
Between Peterson and Bear Creeks is a deposit of peat. The present small size of the bog precludes any development value, under existing economic conditions and energy demands.

The ease of excavation information presented on the geologic resources map delineates portions of the study area where differing excavation conditions can be expected. The three categories — easy, moderate and difficult — reflect the amount and size of rock present. Easy excavation means the largest rocks are less than three inches in diameter, and only hand tools and small loaders are required. Moderate implies that large rocks several feet in diameter may be expected in the finer materials, and heavy equipment may be necessary. Difficult excavation means the material consists of solid rock, and blasting is normally needed.

Contour lines have been drawn on the resources map to show the height above sea level of the deep artesian aquifer. In order to determine the necessary drilling depth to the top of the aquifer, the elevation of the aquifer must be subtracted from the elevation of the drilling site. For example, if the ground level is 3,040 feet and the 2,840 foot contour passes beneath it, the drilling depth to the top of the aquifer is about 200 feet. The data used for these contours have not been field checked, and there is a possiblity of error.

Potential well yields cannot be determined from available information due to well completion practices such as non-perforated well casings and only partial penetration of the aquifer.

GEOLOGY
Resources



▨ Peat bog

🟨 Sand-close to surface

🟫 Gravel-close to surface

🟫 Solid rock - possible riprap or building stone

/ Elevation (MSL) of the top water surface within the aquifer

Ease of Excavation
E Easy
M Moderate
D Difficult

Symbols
sand-gravel operations
exposure of Glacier Peak volcanic ash beds
/// glacial striations
≈ ripple marks
♦ glacial varves

CLIMATE

Climatic information concerning such variables as snow depth, heavy rain periods and wind patterns is valuable for planning. The identification of climatic features such as storm paths and inversions has the obvious benefit of predicting possible danger to life and property.

Certain land use activities may influence microclimatic conditions. For example, vegetation removal may adversely affect temperature and moisture. Increasing the steepness of slopes may decrease available moisture and increase temperature conditions depending upon exposure. Compaction of mineral soil increases soil temperatures and reduces available moisture. Construction may affect temperature, moisture and wind conditions.

Method

The primary source of climatic data is the National Weather Service of the National Oceanic and Atmospheric Administration. The specific data for the study area and the way in which it is presented illustrate the method of climatic inventory for land use planning applied in this project.

Because there are no observing stations within the study area, the small, centrally located community of Swan River was selected for the presentation of data. Significant variations from the information tabulated for Swan River are discussed in each section.

The information has been derived by using climatic data from the nearby town of Creston as most representative of Swan River and applying minor changes based on an analysis of the possible effects of terrain and water features. Temperature and precipitation data are reliable, but slightly less confidence can be placed on wind data because it was derived from more distant Kalispell.

Solar Radiation

The maximum elevation of the sun is significant for planning shade structures, roof overhangs, and window placement. Values of maximum solar elevation in Table 1 are given near the midpoint of each month.

Table 1 — Solar Elevation

	J	F	M	A	M	J	J	A	S	O	N	D
Maximum Solar Elevation (Degrees-minutes)	21-01	29-40	40-16	52-07	61-04	65-22	63-16	55-19	44-29	32-57	23-07	18-35

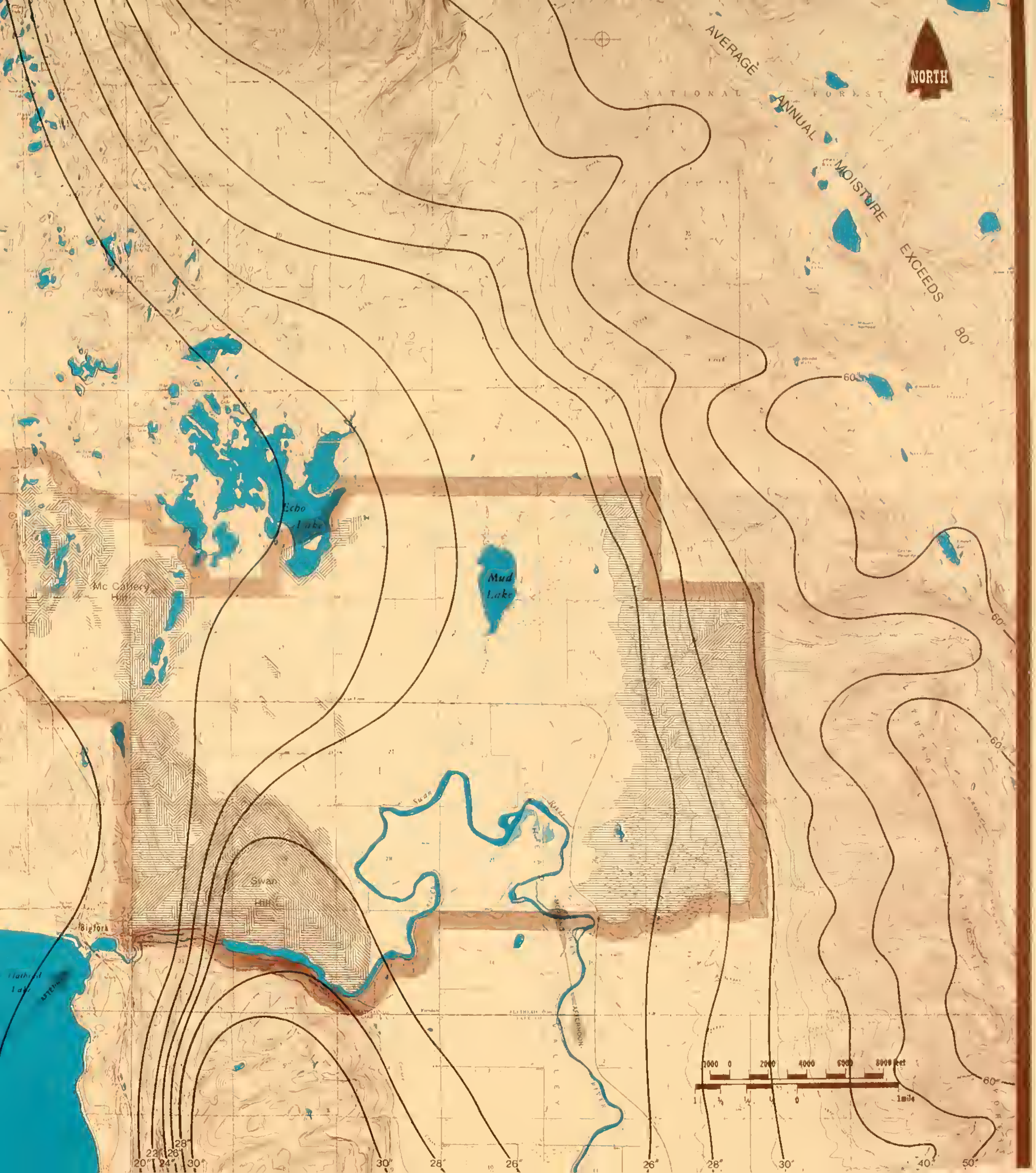
Temperature

In the vicinity of Bigfork on the shore of Flathead Lake, the average minimum temperatures are 3 to 5 degrees warmer than at Swan River. Maximum temperatures, however, are not significantly different.

Table 2 — Temperature (Degree F)

	J	F	M	A	M	J	J	A	S	O	N	D
Average Temperature	22	27	32	43	52	58	64	63	54	44	33	26
Average Maximum	29	35	41	55	66	72	81	81	69	55	40	33
Extreme Maximum	53	56	68	80	89	96	98	98	94	80	63	54
Average minimum	14	18	22	31	38	44	47	46	39	32	25	20
Extreme minimum	-40	-33	-32	4	15	28	32	32	21	7	-30	-41

The length of the freeze-free period at Swan River is expected to average 110 days. On clear, windless nights cold air tends to flow downhill, and the low areas collect "pools" of cold air. Warmer, "well drained" sites with longer freeze-free periods can be expected on the slopes leading upward toward the mountains. The approximate location of these sites can be determined from the slope-aspect map (page 25). The area near Bigfork can be expected to experience a longer freeze-free period with earlier and later dates for the last spring and the first autumn freezes, respectively.



CLIMATE

Iso-lines of equal annual precipitation

Summer wind (normally under 10 mph)

Slope Exposure (study area only)

▨ NE

▨ NW

▥ SE

▤ SW

Moisture

Considerable variation in precipitation can be expected over the study area with changes in terrain and elevation and as the entrance to the valley near Swan Lake is approached. Extreme variations result from local conditions influenced by canyons, mountains, local winds and ground cover.

The expected average precipitation together with the average numer of days (with precipitation greater than .5 inch) are shown in Table 3. In areas where deep snow occurs it is helpful to have some knowledge of maximum and average montbly snowfall for road and residential uses.

Table 3 — Precipitation (Inches of Water)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
Average	1.9	1.2	1.1	1.3	2.3	3.4	1.5	1.6	1.6	1 7	1.6	1.8	21.0
Days with .5	1	1		1	1	3	1	1	1		1		11
Snow & Sleet (Inches of Depth) Maximum total fall	34	30	17	11	2	0	0	0	0	1	10	31	108.0
Average total fall	20	11	7	1	1	0	0	0	0	1	7	17	64.1

Wind

Data on prevailing and maximum wind direction and speed are adequate for most planning purposes (see table 4). The wind data presented are based on summer conditions. The prevailing winds in the valley are normally light (under 10 mph). Pronounced valley winds occur in the southeastern portion of the study area. Maximum winds are related to thunderstorm activity.

In the western portion of the study area, and particularly near Bigfork, afternoon winds move away from the morning winds toward Flathead Lake. This land-sea breeze effect is most pronounced in summer.

Table 4 — Wind

PREVAILING WIND ESTIMATE (MILES/HR)

	J	F	M	A	M	J	J	A	S	O	N	D
Direction	W	SW	SW	SW	SW	SW	SW	SW	SW	W	W	W
Speed	under 10 miles/hr											

MAXIMUM WIND ESTIMATE (MILES/HR)

	J	F	M	A	M	J	J	A	S	O	N	D
Most Probable Directions	NE	NE	NE	SW	VARIABLE				SW	NE	NE	NE
	SW	SW	SW							SW	SW	SW
Speed (MPH)	55	55	50	45	40	40	40	40	45	50	50	55

Inversion-like Climatic Condition in the Study Area

Air Quality

Air quality measurements have not been made in the study area. Kalispell is the closest locality for which information is available, and those studies were conducted in 1963-1964 and 1960-1970.

The high frequency of inversions in the Flathead Valley, as ascertained by visual observations made by National Weather Service personnel during the 1963-1964 air quality study, is indicated in Table 5.

There is a lack of adequate information on wind, stability, and mixing depth for determination of the dispersion of pollutants from the Kalispell area. However, existing studies provide baselines and evidence of actual and potential pollution problems.

Although better air quality can be expected in the study area than at Kalispell, light winds and frequent temperature inversions make the area vulnerable to air pollution problems. Therefore, an assessment of air pollution potential is of extreme importance when activities involving the disposal of wastes in the atmosphere are considered.

Table 5 — Inversion Occurrence (Days)

	J	F	M	A	M	J	J	A	S	O	N	D
Night	no data						26	28	27	26	11	23
Day (6AM-6PM)	no data						22	26	27	26	10	25

Comfort

Warm season comfort is dependent upon temperature and moisture, and cold season comfort is contingent upon temperature and wind. However, because high humidities in the study area occur only with cool temperatures, it is possible to simplify this discussion for general planning purposes by considering only temperature and wind in both summer and winter.

Temperatures in combination with the prevailing light winds, can be examined with the aid of a windchill index (see Appendix B) to gain an insight into comfort.

The average maximum temperatures in the middle 70's and low 80's, in combination with the 5 to 10 mph winds, are near the "pleasant" index. The average minimum temperatures near 15° to 20°, in combination with 5 mph winds, are near the "cold" and "very cold" index.

The prevailing moderate conditions in the area combine to provide a total impression of a cool, relatively dry climate with four distinct seasons. Intruding infrequently upon this pattern of pleasantness is an occasional "hot" summer day or winter "cold spell."

Competition is increasing for an essentially fixed supply of water for a wide array of uses.

If we understand hydrologic tolerances and limitations and apply this knowledge, development need not lower the quality of our water resources.

Method

Hydrology is a significant consideration in any land use planning effort, but its absolute importance depends on the area under investigation and the planning objectives. The type of information needed should then be determined. For broad planning, very detailed information is probably not necessary, and much of it may in fact be obtained from aerial photography.

Depending on the type of hydrologic data desired, there are a variety of possible sources of existing information. If the U. S. Forest Service administers land nearby, its personnel can supply data on any of their management activities that may affect the planning unit. If there are live streams or lakes in the unit, the Montana Departments of Fish and Game and Health and Environmental Sciences may have data on fisheries and water quality. The Montana Department of Natural Resources and Conservation, Water Resources Division, or the U. S. Geological Survey may be able to supply information on ground water, wells, irrigation systems, flood hazard areas and water rights. The Bureau of Land Management is also involved in multi-objective land planning and may have available data. Often an excellent source of historical and on-site data is the local residents. After information availability is compared with data needs, a determination may be made as to what must be collected.

In many Montana planning areas, water quantity may be the hydrologic parameter of most importance to local planners. Fortunately, a considerable amount of water quantity information (particularly for surface water) has been collected and published by the U. S. Geological Survey. These Data are generally printed in tabular form and consist of daily, monthly, and annual flow figures for selected gaging points on most major streams and tributaries.

However, most smaller Montana streams are not adequately gaged. Estimating flow quantities for ungaged areas requires a trained hydrologist, but reasonable estimates can usually be made in a short time. This kind of assistance can be obtained from some engineering-consultants.

Rising Water Level – Johnson Lake, 1972

Under state law, flood hazard areas must be determined on the basis of the 100-year frequency flood. This determination generally requires expensive and time consuming hydraulic-engineering studies. Requests for detailed flood information studies should be directed to the Montana Department of Natural Resources and Conservation in Helena.

For broad-level planning purposes, and prior to the completion of detailed studies, approximate flood plain limits can often be determined by aerial-photo interpretation, detailed soils maps or past flood records. These methods may produce suitable flood plain delineations in a short amount of time.

An attempt was made to delineate the 100-year Swan River flood plain by near-infrared photo interpretation, but the results were unsatisfactory. The study area lacks the prominent land-relief features necessary for adequate photo delineation. Delineation through photo interpretation seems most promising for younger streams without broad, flat flood plain areas.

Present pollution sources must also be identified. Some areas of pollution can be located through the use of various types of aerial photography, which must then be supplemented by field checks. All types of water contaminants are important, including biological pollutants, detergents, natural and man-caused sediment and industrial wastes. The Montana Department of Health and Environmental Sciences, various other agencies, or the universities can aid in water quality testing.

Streams should be classified by a trained observer using the technique of sampling reaches of streams that differ in stability. Differences within a single stream are caused by physiographic changes, geology, human influences, and tributaries having varying characteristics. Stability indicators are rated for each reach of stream and then averaged to obtain an overall stream rating. Generally, the overall stability of a stream is governed by its most unstable reach.

Special hydrologic considerations in land planning will develop in each situation and will usually warrant field investigations. In this study, the rising lakes were a special problem, and, although no solutions have been reached, investigation has shown that it is largely a natural occurrence somewhat influenced by man-caused disturbances.

Area Hydrology

The general surface features of this area include a rolling valley dotted with pothole lakes and slow moving, swampy streams. The terrain rises steeply toward mountain peaks in the east from which clear mountain streams flow. Beaver dams, depressions, and subsurface hardpan layers have resulted in many areas of swamp and high water table in the valley.

The pothole lakes in this area have no surface inlet or outlet with the exception of Echo Lake, which has an inlet. Being almost totally dependent on ground water for recharge, they rise and fall in response to fluctuations in the ground-water level. Water levels begin to rise in the spring, reach a maximum in the fall, and then decline through the winter. The autumnal peak results from the time needed for the spring recharge from the mountains to reach the valley via ground-water flow. This cyclic rise and fall, which can exceed ten feet per season, is further complicated because the absolute height that the water attains in any one year is dependent not only upon precipitation but also evapotranspiration rates, which are in turn functions of various climatic controls such as temperature and humidity.

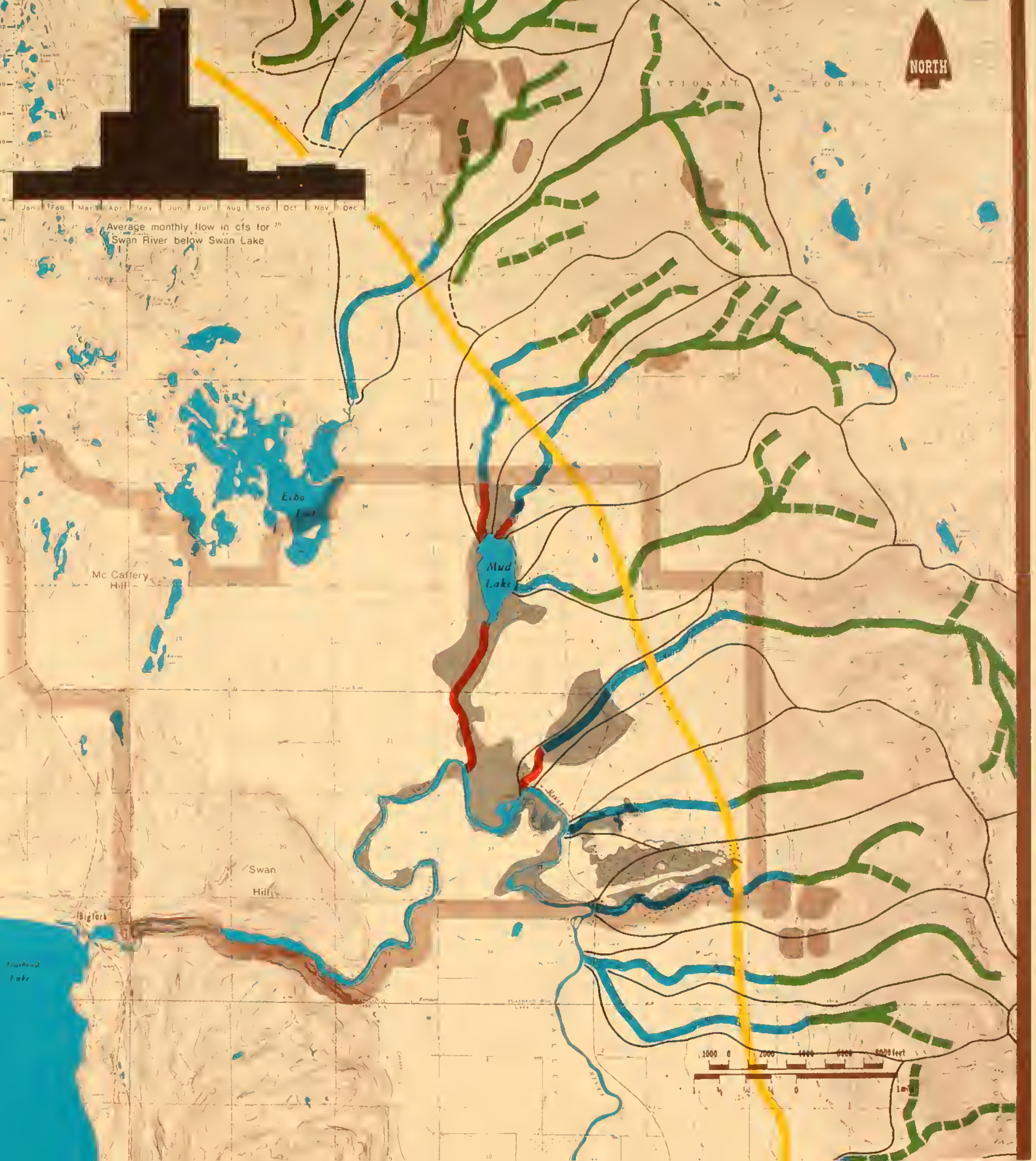
On the watersheds above the study area, many acres of forests have been harvested in recent years. When trees are removed from an area, the annual water yield is increased due to reduced transpiration. The same effect may result from any type of development that clears vegetation, thereby causing greater and more concentrated runoff.

Stream Classification

Streams, vital parts of ecological systems, are dynamic yet in balance with their environment under ideal conditions. Man, however, often interrupts this system, sometimes causing the streams to adjust to channel changes too rapidly. Activities such as vegetation removal, grazing, and construction tend to increase stream-flow and surface runoff. A significant increase in the volume of water places an excessive load on the stream channel and can cause flooding, severe erosion, pollution, and other damage.

Stream channels in various stages of development have different channel conditions. These conditions, dependent upon location and outside influences, are indicative of the stability of the channel. This, in turn, indicates the stress or increased load that the channel can tolerate.

The U. S. Forest Service has developed a classification system based on the above criteria which was applied in this study (see map page 29). If a channel is in a state of rapid change, it will generally look "new," with bright rocks, nonvegetated banks, bank undercutting, deposition, and low vertical channel sides. Characteristics of stability include a well-incised channel, vegetated banks, moss covered boulders and rocks, and little silt and clay on the bottom. A relatively new stream geologically (actively downcutting) may be classified as stable, while a geologically old, meandering stream may be an unstable stream in this system.



HYDROLOGY

— Watershed boundaries

Stream classification

- 🟩 high stability
- 🟦 medium stability
- 🟥 low stability

🟨 Groundwater recharge boundary

▨ High water table
Swamps - Flood plain

▨ Clearcut forest areas

Hydrologic Limitations

FLOOD PLAIN

Periodic flooding is one of the most critical constraints to development in an area where streams are present. Indeed, large floods are so destructive and hazardous that special legislation has been adopted by most states to regulate human activity in flood-prone areas.

In Montana, the Floodway Management and Regulation Act of 1971 authorizes the Montana Department of Natural Resources and Conservation to initiate a comprehensive program for flood plain delineation and regulation for all Montana waterways. Under this law, a floodway is officially designated and minimum standards promulgated by the Department. Then the local political body must adopt adequate flood plain land use regulations or State regulation will be implemented. Even on non-delineated floodways local governments should consider enforcing land use regulations along all major waterways.

In the study area, approximate flood plain limits for the Swan River have been delineated by the U. S. Geological Survey on the basis of high-water profiles from previous floods. This information provides a reasonable approximation of the 100-year frequency flood limits, but, because only a limited amount of field work was done, the location of the flood-limit lines are imprecise.

1916 Swan River Flood, Section 27

GROUND WATER

The underground water in the Bigfork study area is one of the most critical factors affecting development. Ground water quality is presently good, but problems may develop if it is not properly managed.

Water shortages have been noted in the shallow sand aquifer northeast of Swan Hill during dry years (see geologic resources map page 23). However, pollution of this shallow water could have a more lasting effect.

Ground water under Swan and McCaffery Hills occupies only the narrow fractures in the rock, so well drawdown can be expected to be great and yields poor. The vertical fractures, however, permit rapid downward movement of effluents from septic tanks into aquifers.

Well records indicate that a fairly productive artesian aquifer exists about 200 to 250 feet below the valley floor. The confining pressure causes the water's level to rise up and even out of the wells. There is little danger of contamination of this aquifer from the surface.

Dry Well, 405 feet deep

HIGH WATER TABLE

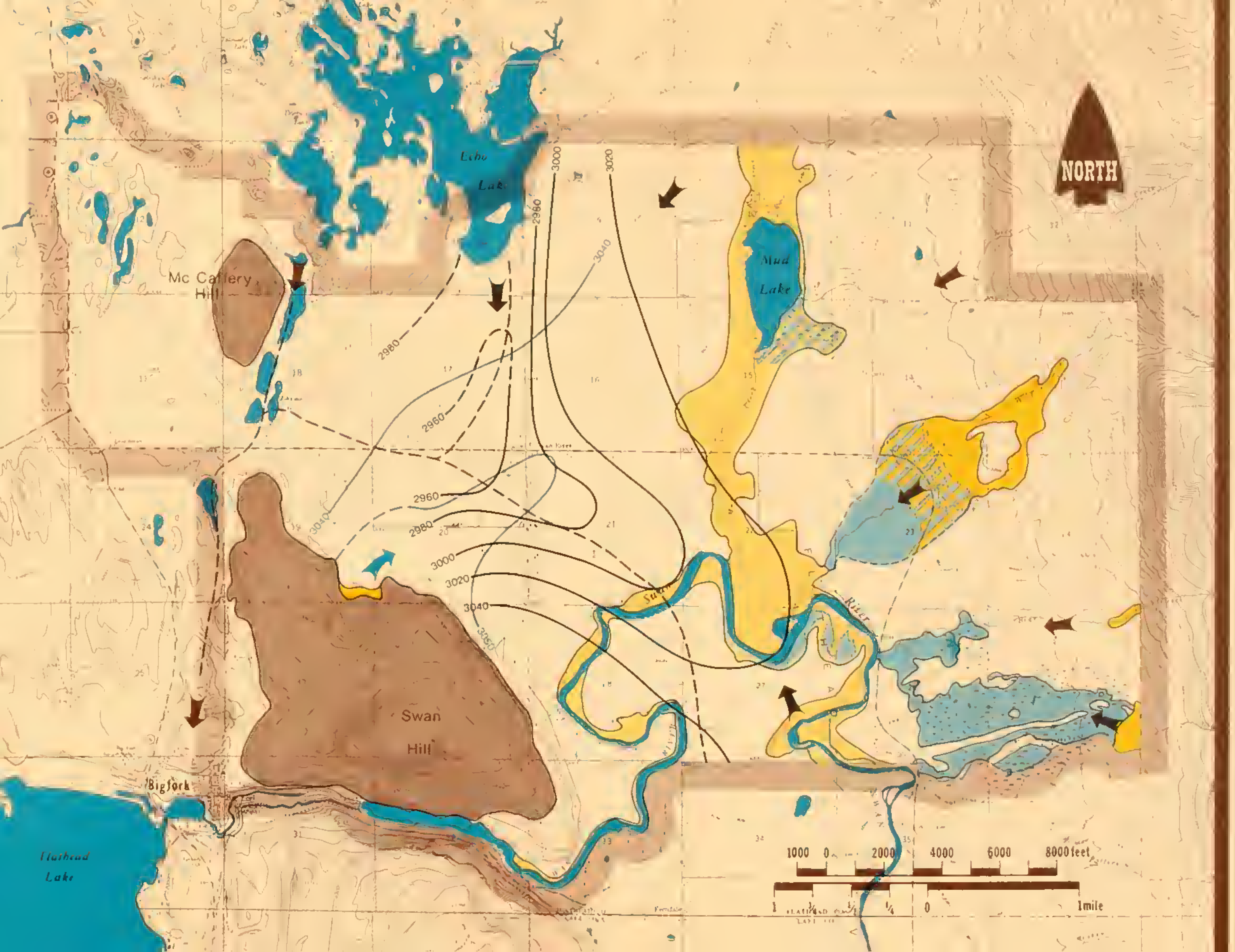
High water exists where the land surface is relatively low. Numerous places in the study area are often flooded and swampy. Very shallow ground water is found in the flood plain, the alluvial deposits (between the recharge and discharge areas) and near the swamps. A swamp or natural lake is merely a low spot where the water table is above the land surface.

Water table depth is important from the standpoint of pollution. Effluent from poorly designed septic tank systems can percolate directly to the ground water without enough filtering action of the soil to purify wastewater in such areas. Only completely contained sewage disposal systems are acceptable because of the danger of water contamination and associated health hazards inherent in the use of conventional systems.

High water table causes problems with basement flooding and highway construction. A "grass roots" water table is essential to most plants with high evapotranspiration rates.

Swamp, Northwestern Portion of Study Area

HYDROLOGY
Limitations



- 🟨 100 year flood prone area
- 🟧 Ground-water recharge area
- 🟦 Ground-water discharge area (striped areas indicate discharge within the hydrologic feature)
- 🟫 Impermeable
- 3040 Elevation (MSL) contours of the water table within the dune sand aquifer
- 3040 Elevation (MSL) contours of the water table within the deep artesian aquifer
- Approximate location of suspected stream channel aquifer
- Direction of ground water flow; colors correspond to different aquifers

Accuracy of contours has not been verified in the field.

CRITICAL WATER AREAS

Historically, man has been attracted to water bodies for transportation, industry, recreation and, more recently, waterfront residences and second homes. The fragile water-wetland systems that are least able to withstand impairment are being subjected to the greatest impacts. These critical areas incude lakes and shorelines, streams and their corridors, swamps, ground water recharge areas, and aquifers. Before protective measures can be taken, these features must first be identified and described.

The usual results of urbanization on water-wetlands are increased flooding, erosion and sedimentation and decreased water supply and quality. These effects are prompted by unavoidable consequences of urbanization such as loss in natural vegetation, greater use of water and discharge of wastes, and an increase in impervious surfaces. It may be generally stated that the damage to water resources is most severe when development, resulting in a large, impervious surface, occurs close to the water body on steep, non-vegetated slopes.

Urbanization affects both quality and quantity of water. The influx of waste material increases dissolved solids, thereby decreasing the dissolved oxygen content. Secondly, less water may percolate to recharge ground water due to larger areas of surface made impermeable.

Even uses that are inseparable from waterfront areas can diminish the present or future value of surface water for supply, recreation or aesthetics. Swamp areas should be identified as important areas for flood and water storage, wildlife habitat and fish spawning ground.

The valuable ground-water resource should be not only protected but carefully managed. All potential land uses which involve the disposal of toxic wastes, biological discharges or sewage should be examined as to possible damage to aquifers.

Ground-water recharge areas are the points of interchange from surface water to aquifers. The movement of ground to surface in turn contributes to streams during low flow periods. Development in these porous areas is critical, because it can prevent the infiltration of water into aquifers.

Since there is only a finite amount of water available to aquifer recharge areas, the potential aquifer supply limits development. The over-development of a ground-water resource in a small area can deplete the supply for a much larger area. Heavy draw-down can also cause land subsidence. The limits of our ground-water resources should be identified to prevent development from exceeding the aquifer's capacity.

Riverfront Excavation, Section 28

View to the East on Echo Lake in 1936

Same View in 1973 Showing Rise in Water Level

Planners need soils information to help identify developmental limitations for various uses such as roads, residences and septic tank drainfields. The application of this information can aid in preventing surface and ground-water pollution as well as costly mistakes in construction. Soils information is also useful in broad-level inventories to differentiate productive agricultural land from those areas more suitable for other uses.

Method

A soil survey is an inventory of soil resources in a given area, usually a county. The soil survey report includes a map showing the location and extent of soils, descriptions of the soils, and explanations of how they can be used and managed.

Soil surveys provide information for each soil series, and soils interpretations are an essential part of any land use planning program. Interpretations provide information that is used to predict the response of various soils to different uses. The limitations of various soils in an area are thereby indicated, which will lead to an assessment of alternative uses for the same soil or a choice between several soils for a given use. This process improves soil management practices.

Soil surveys are tailored to the economy of an area. For example, if the survey emphasis is on livestock grazing, more detailed site surveying may be necessary for higher intensity uses such as residential development.

The first inventory step should be an extensive search for available resource data. Some soils information is available for most areas in Montana. The information may range from broad reconnaissance soil surveys, provided by the Montana Cooperative Extension Service, the U. S. Soil Conservation Service (SCS), the Bureau of Reclamation and the Forest Service to detailed soil surveys published for seven Montana counties thus far and available from the Soil Conservation Service. The SCS has county soil surveys in progress in ten counties and many soil studies for smaller areas which are recorded on aerial photos.

Other than soils surveys, there are a variety of sources useful in collecting interpretive data. The best local source of soils information is the Conservation District and the local Soil Conservation Service district office.

Soils field work in the study area consisted of checking the detailed 1953 Soil Conservation Service soils survey for reliability, and generally the survey was found to be extremely accurate. Only those soil mapping units rated severe or moderate for residential use were field checked.

Since digging soil pits is time consuming, road cuts should be used wherever possible. An augur may be sufficient to determine such physical characteristics as depth, parent material, structure, coarse fragments, and per cent of sand, silt and clay.

Clay soils should be analyzed for shrink-swell characteristics which may not be noted in agricultural soil surveys. Soils on slopes should be carefully checked since slippage hazard is severe on slopes underlain by shale or any clay-textured parent material.

Remote sensor data for soils mapping should be used in conjunction with field studies. Very general soils information may be obtained by studying the vegetation on infrared photographs. Areas of high water table can be readily delineated, as can abrupt topographic changes. Photography is very useful in identifying general soil patterns, drainage and flood plain characteristics. However, per cent slope and subsurface soil characteristics cannot be accurately determined.

After studying aerial photographs, all available soil surveys and other resource studies, a map showing soil characteristics and problems may be made for use in reconnaissance field checking.

If little soils information is available, it is advisable to make at least a reconnaissance soil study. Aerial photographs and topography maps may be used to identify land forms, geologic formations and visable drainages. Within the delineated areas, test holes should be dug and observations made of soil textures, structure, color, depth and parent material. The soil profile should be located on a map and logged, and samples should be collected for laboratory analysis.

Local landowners may be able to indicate the locations of suitable roadbeds, flooding, high water table, erosion, poor plant growth and other undesirable features which will provide valuable clues for field testing.

Area Soils

Much of the Bigfork study area has been influenced by alpine glaciation. The area is covered with material that was scoured, mixed and redeposited either by ice or by water as the ice melted. Variations in soils result from changes in geologic material caused by topography, climate and living organisms, particularly vegetation.

The Great Soil Group most widely represented in the study area is Brown Podzolic. The most striking feature of these soils is the brown or reddish-brown horizon immediately beneath the forest litter, which may extend to a depth of twelve inches. Timber and Christmas tree production are important uses of these soils.

As an indication of diversity eight soil associations occur within the study area. A soil association is a group of soils that are geographically associated in a repeating pattern on the landscape. Although consisting of one or more major soils and at least one minor soil, the association is named for the major soils. Soils with similar profiles make up a soil series. Except for a difference of texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics.

Generally, the soils in the Bigfork area are composed of glacial till, fluvioglacial and glaciolacustrine valley fill, and recent alluvium. Therefore, the soil pattern over much of this area is extremely complex. The soils vary considerably in texture, depth, and the amount and size of coarse fragments on the surface and in subsurface layers.

For more detailed information on Bigfork Study area soils, see the **Soil Survey Report of the Upper Flathead Valley**, Soil Conservation Service.

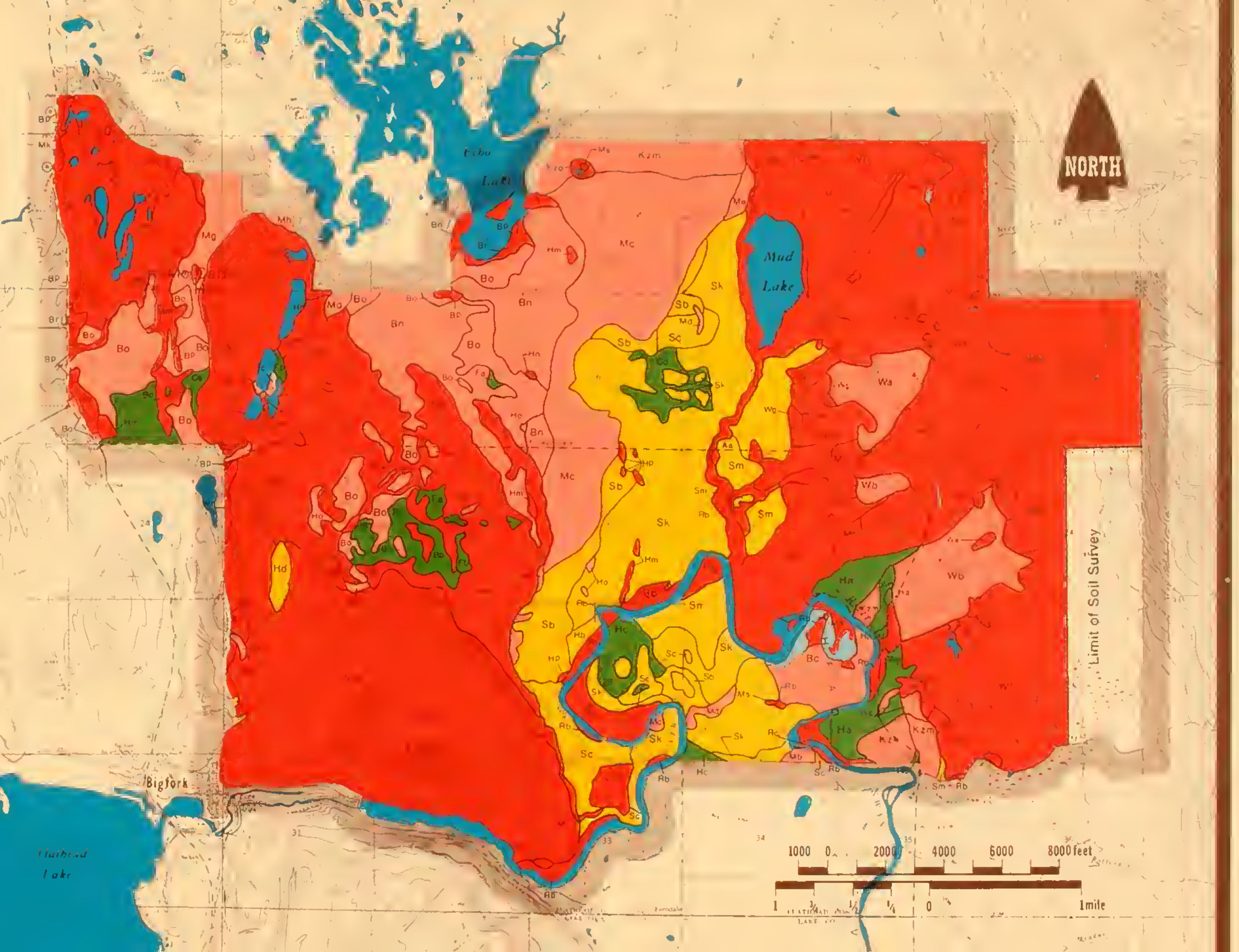
Agricultural Capability

Soils are grouped into a land capability classification system and rated in terms of eight broad classes according to: (1) their adaptability for farm crops under permanent agriculture; (2) their anticipated responses; (3) their limitations for sustained production; and (4) the risk of soil damage in the event of mismanagement. The groupings in this case are based on relative suitability of soils for tilled crops, hay and pasture. The map (page 35) shows four classes of agricultural capability for tilled crops.

Classes I & II:	Prime agricultural soils with slight limitations that reduce crop yields. The limiting factors may include low moisture-holding capacity and slightly undulating and sloping terrain.
Class III:	Soils have some moderate limitations requiring care in plant selection and/or special conservation measures. The hazards are wind erosion, low moisture-holding capacity, wetlands and stony land.
Class IV:	Soils have severe limitations and should be cultivated only occasionally or only under very careful management. The areas can produce Christmas trees and also pasture grass if rotated every one or two years with small grains. Problems may be those of low fertility, slow permeability, high erosion or shallow soils.
Classes V & VI:	Soils have very severe limitations and should be restricted to grazing, extensive recreation and timber management uses. Careful management of wetlands, steep slopes and shallow and stony soils in these classes is necessary or vegetation will disappear. Soils will then revert to Classes VII and VIII which have virtually no productive value.

AGRICULTURAL CAPABILITY

Tilled Crops



- 🟩 Class I, II
  Slight limitations
- 🟨 Class III
  Moderate limitations
- 🟥 Class IV
  Severe limitations
- 🟥 Class V - VIII
  Very severe limitations

Slope

The degree of slope is very important in slope stability because steepness affects runoff from snowmelt and rain. Steep slopes often generate higher runoff velocity and susceptibility for erosion than gentle slopes. Land instability from such factors as seismic hazards may also be extremely serious on slopes greater than 25 percent, and the risk increases as these steeper slopes are developed.

High Erosion Hazard – Steep Riverfront Slopes, Section 28

The erosion hazard of slopes is also influenced by soil texture, permeability, parent material and vegetative cover. A gentle slope devoid of vegetation with shallow, light-textured soils may have a higher erosion potential than a steep slope with medium-textured soils and good vegetative growth.

The slope analysis in this study was begun with the objective of determining slope classes that would be generally applicable to most regions of Montana. Soil scientists from the Soil Conservation Service recommended the six-class system presented in the map on the following page because those classes, representing a medium range for a wide variety of land uses, are most compatible with soil surveys.

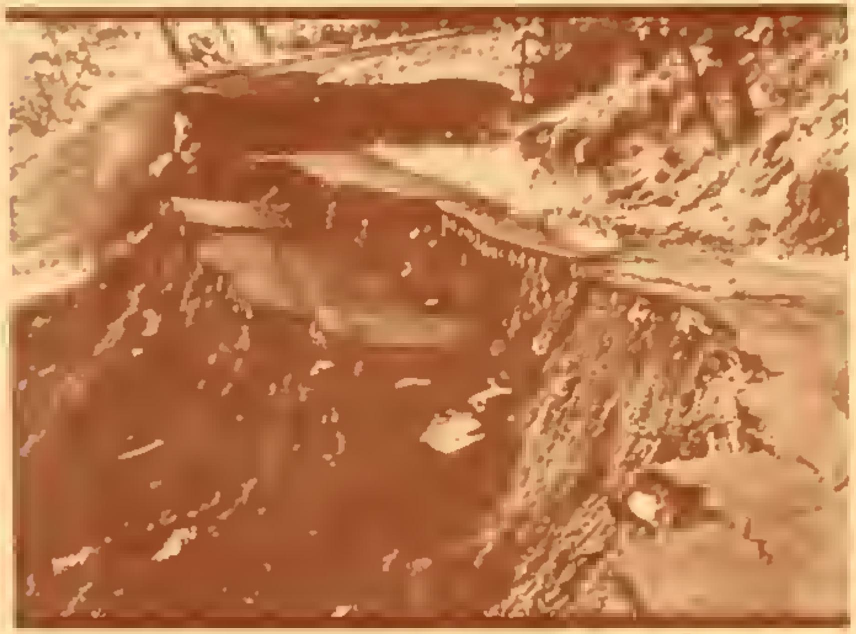
The other alternative would have been to select slope classes specific to the study area. Generally, the slope-soils limitation ratings for residential use and roads in the study area are 0-8% (slight), 8-15% (moderate), and over 15% (severe).

The generalized classes used in this project cannot be recommended as a standard slope breakdown for Montana. Variability in engineering properties and soil conditions make standard slope classes meaningless. For example, slope per cent is not the sole indicator of slope stability since very stable soils may exist on a steep slope.

The slope map is, however, an excellent visual reference for general planning since steepness of slope may interact with geology, soils, hydrology, and vegetation to form developmental limitations or opportunities.

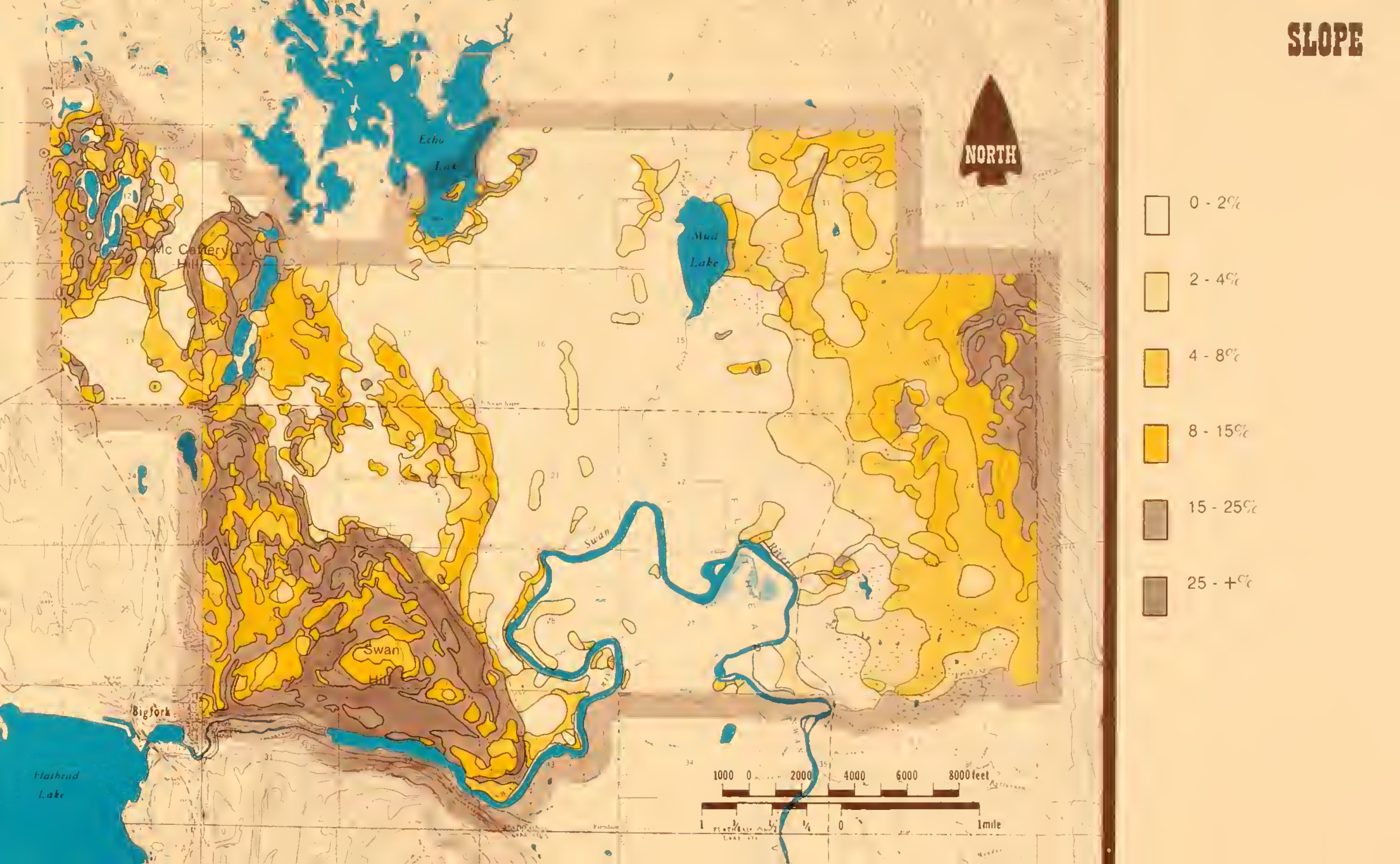
The slope map shown on page 37 was constructed manually with six slope classes, both 20 and 40 foot contour intervals and a map scale of 1:24,000. This proved to be extremely time consuming.

Although a slope map can be a useful planning tool, it may not be sufficiently valuable to justify the time and expense of the manual process used in this study. The U. S. Geological Survey has developed a photo-mechanical process for slope classification which can be used with any U.S.G.S. quadrangle map. Five broad slope classes can be done for a 7½ minute quadrangle map (approximately 54-60 square miles). The cost of constructing a slope map through this process is significantly less than with manual techniques.



Erosion from Concentrated Runoff Can Cause Severe Road Damage

SLOPE


NORTH
0 - 2%
2 - 4%
4 - 8%
8 - 15%
15 - 25%
25 - +%
Echo Lake
Mud Lake
Mc Caffery Hill
Swan River
Swan Hill
Bigfork
Flathead Lake
1000 0 2000 4000 6000 8000 feet
1 ½ ¼ 0 1mile

Soil Limitations

ROADS

Soils limitations for roads are based on those features of soils that affect performance and durability of roads. For example, the hazard of road breakage is higher in clay soils than in gravel and sandy material. Silts are more susceptible to frost heave than clays or sandy soils. Depending upon topography in relation to soil and substrata, extreme land slippage occurs even on gentle slopes in some areas of Montana.

It should be noted that the assignment of a moderate or severe rating is not intended to prohibit the use of a soil for a particular purpose. Rather, the ratings emphasize that there are hazards to be considered and that alternatives in design are needed to overcome the limitations.

Table of Soils Limitations for Roads

Limiting Factors Affecting Use	Degree of Limitation		
	Slight	Moderate	Severe
Depth to high Water Table	More than 36"	20 to 36"	Less than 20"
Flooding hazard	No more than once in 10 yrs.	No more than once in 10 yrs.	More than once in 5 years
Load-bearing capacity (AASHO rating)	A-1 to A-3	A-4 to A-5	A-6 to A-7
Frost heave potential	Low	Moderate	High
Stoniness	Very stony	Extremely stony	Stone land or rubble
Depth to rock	More than 36"	20 to 36"	Less than 20"
Topography (slope range) for parking for roads	 0 to 3% 0 to 8%	 3 to 8% 8 to 15%	 Over 8% Over 15%

Other properties unique to a particular soil which may affect its use for roads are high shrink-swell and erodibility. Source of all Tables of Soils Limitations: U. S. Soil Conservation Service, **Engineering Properties and Soil Interpretations for Use In Resource Planning and Development**, July 1970.

Limiting Factors For Soil Mapping Units In the Bigfork Study Area

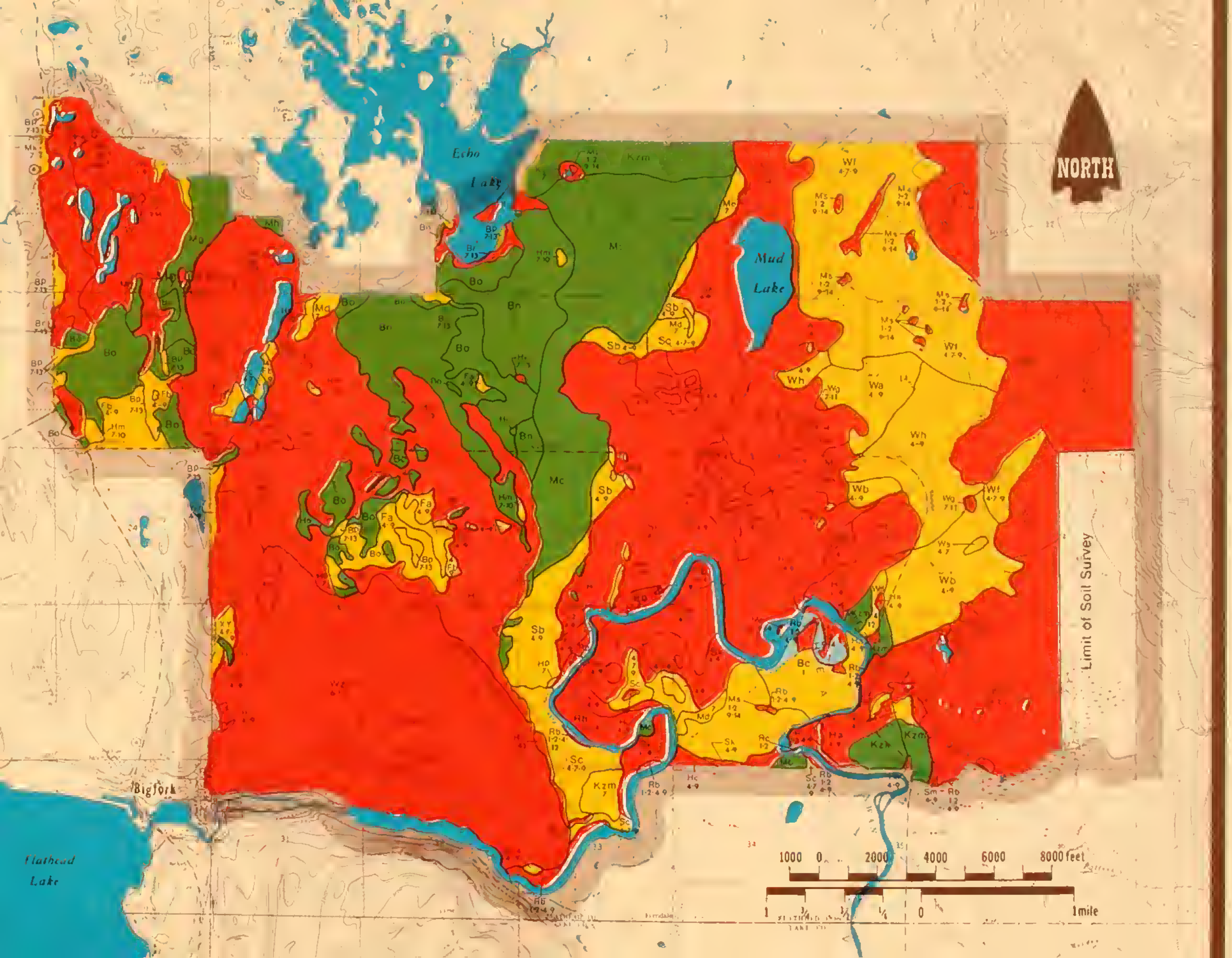
Kinds of limitations are indicated on the map by these numbers for moderate and severe conditions.

1. Flooding or ponding
2. Seasonal water table
3. Shrink-swell potential
4. Frost heave potential
5. Poor compaction quality
6. Soil depth to bedrock
7. Unfavorable slope
8. Slow permeability
9. Unfavorable load-bearing capacity
10. Unfavorable surface texture
11. Unfavorable amount of gravel, cobble or stone
12. Ground water pollution hazard
13. High erosion hazard
14. High organic matter content
15. Slippery or sticky when wet

NOTE: These interpretations and the accompanying soils maps are for general planning. On-site investigation is needed for specific design and construction.

SOIL LIMITATIONS

Roads



🟩 Slight

🟨 Moderate

🟥 Severe

RESIDENTIAL

Sound uses of soils in urbanizing and recreational areas depend on a number of relevant soil properties. The most important are texture, permeability, natural drainage and variation in arrangements of soil layers.

Generally, the soils limitations rating for residential use is based on suitability for foundations, but other factors such as slope, hydrologic conditions and depth to bedrock, must be considered.

Foundations for low buildings with basements are affected by soil properties similar to those discussed in road building, for frost heave and shrink-swell can cause cracking and weakening. Other factors include flood hazard and high cost of construction in bedrock.

Table of Soils Limitations for Building Sites in Residential Developments With Public Sewage Disposal

Limiting Factors Affecting Use	Degree of Limitation		
	Slight	Moderate	Severe
Shrink-swell behavior	Low	Moderate	High
Depth to seasonal high water table[1]	More than 72"	36 to 72"	Less than 36"
Flood hazard	Never	Less often than once in 100 yrs.	More often than once in 100 yrs.
Slope	0 to 8%	8 to 15%	Over 15%
Depth to bedrock	More than 60"	36 to 60"	Less than 36"
Stoniness or rockiness	Stony	Very stony	Extremely stony
Salinity or alkalinity (salts)	Slight	Moderate	Strong

---

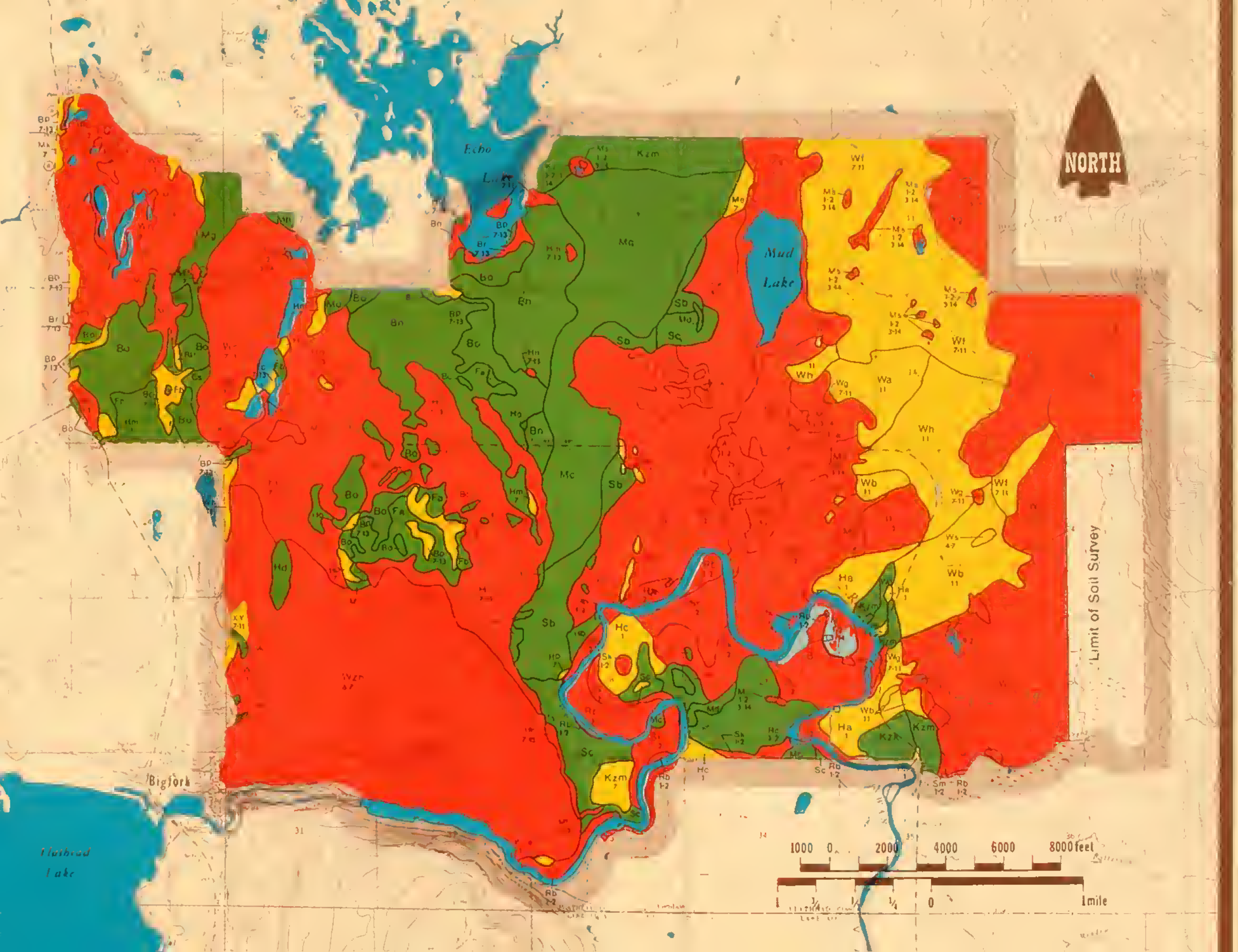
[1] Residential development without basements would have less severe restrictions for water table and depth to rock.

Limiting Factors For Soil Mapping Units In the Bigfork Study Area

Kinds of limitations are indicated on the map by these numbers for moderate and severe conditions.

1. Flooding or ponding
2. Seasonal water table
3. Shrink-swell potential
4. Frost heave potential
5. Poor compaction quality
6. Soil depth to bedrock
7. Unfavorable slope
8. Slow permeability
9. Unfavorable load-bearing capacity
10. Unfavorable surface texture
11. Unfavorable amount of gravel, cobble or stone
12. Ground water pollution hazard
13. High erosion hazard
14. High organic matter content
15. Slippery or sticky when wet

SOIL LIMITATIONS
Residential w/Basement



🟩 Slight

🟨 Moderate

🟥 Severe

SEPTIC TANK DRAINFIELDS

The first consideration when planning a septic tank sewage disposal system is whether the soil is suitable for absorbing and filtering the liquids that flow from the drainfield. The efficiency and longevity of a private sewage disposal system depend largely on the absorptive capacity of the soil. Filtering by the soil removes odors and averts contamination of ground water. It also prevents a concentration of unfiltered sewage which, if it reaches the ground surface, would result in offensive odors and possibly of disease.

Before installation of a septic tank, the absorptive ability of the soil must be examined in order to determine the proper size filter field in conjunction with the type of soil on the site.

The map on the following page shows areas in which septic tank limitations might exist. The criteria for the limitations of slight, moderate and severe include permeability, parent material, flood hazard, slope, and depth to bedrock or other impervious layers. Slow permeability is often a result of heavy clay textures.

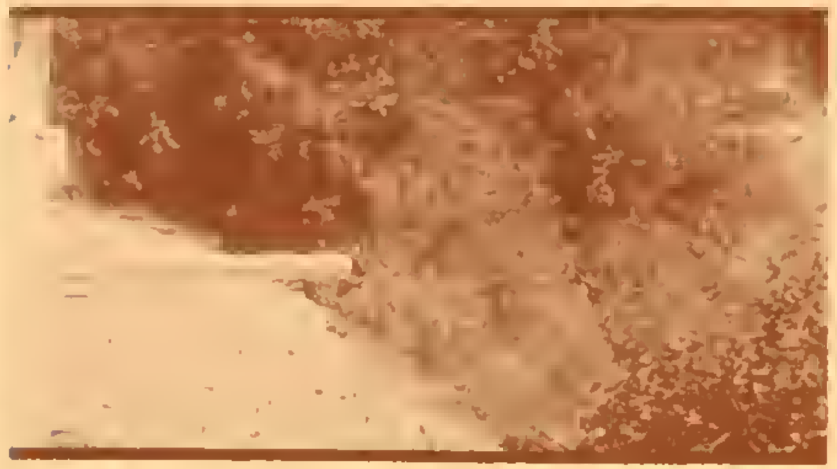


Table of Soils Limitation for On-Site Disposal Systems

Limiting Factors Affecting Use	Degree of Limitation		
	Slight	Moderate	Severe
Soil permeability rate	More than 1 in/hr[1]	.63 to 1 in/hr	Less than .63 in/hr
Depth to bedrock[2]	More than 6'	4 to 6'	Less than 4'
Seasonal high water table	More than 6' below surface	3 to 6' below surface	Less than 3' below surface
Slope	0 to 5%	5 to 10%	Over 10% [3]
Stoniness	Stony to very stony	Very stony	Extremely stony to stony land
Flooding	Never	Never	Occasional to Frequent

[1] Possible pollution hazard to surface water and ground water supplies where permeability rates are rapid.

[2] Creviced, shattered or dissolved passageways in limestone bedrock may not adequately filter effluent and present a pollution problem.

[3] Slopes greater than 10 percent have severe limitations because unfiltered effluent may surface on the downhill slope.

Current Montana Department of Health and Environmental Sciences standards for septic tank system design and installation should be followed where on-site disposal systems are planned.

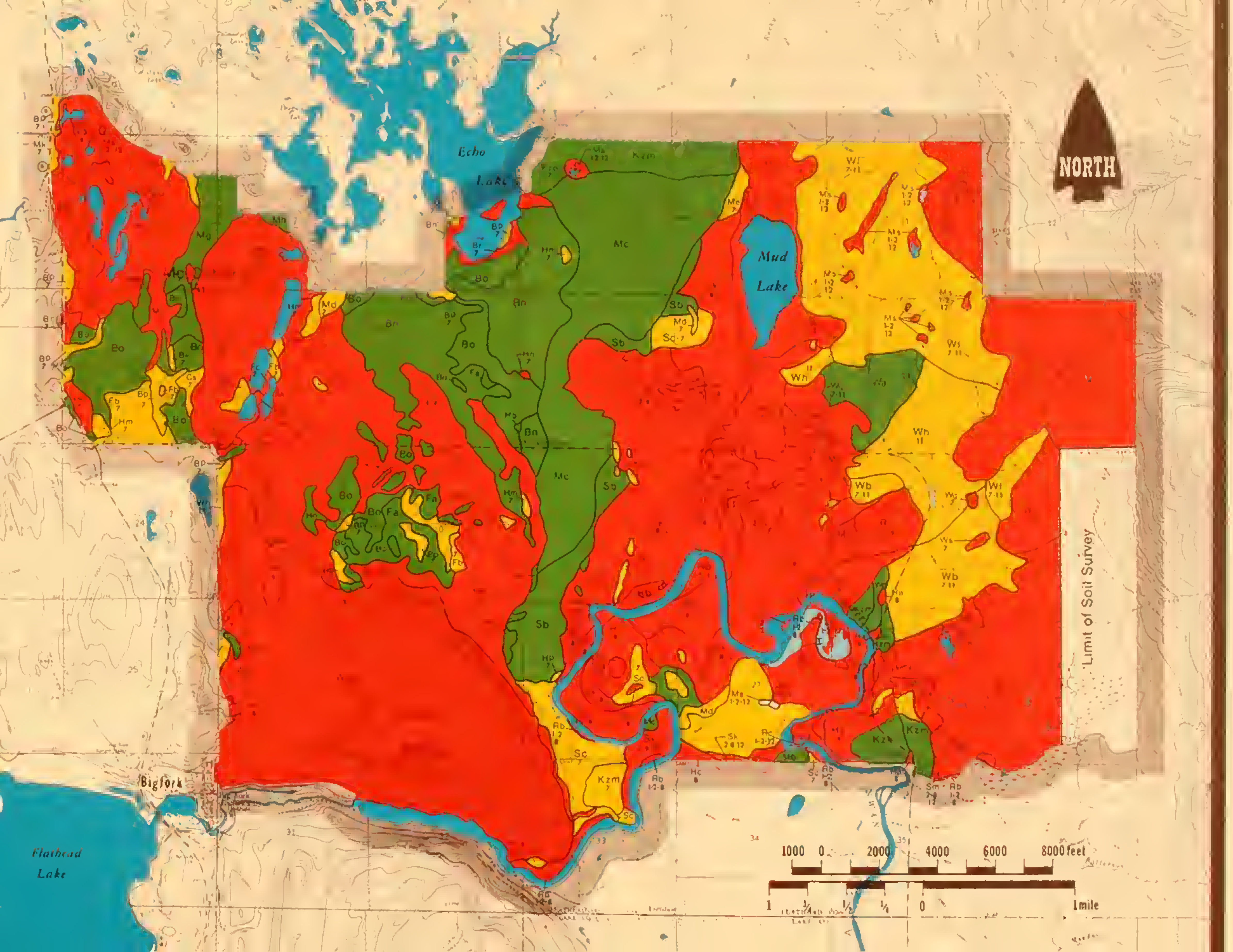
Limiting Factors For Soil Mapping Units In the Bigfork Study Area

Kinds of limitations are indicated on the map by these numbers for moderate and severe conditions.

1. Flooding or ponding
2. Seasonal water table
3. Shrink-swell potential
4. Frost heave potential
5. Poor compaction quality
6. Soil depth to bedrock
7. Unfavorable slope
8. Slow permeability
9. Unfavorable load-bearing capacity
10. Unfavorable surface texture
11. Unfavorable amount of gravel, cobble or stone
12. Ground water pollution hazard
13. High erosion hazard
14. High organic matter content
15. Slippery or sticky when wet

SOIL LIMITATIONS

Septic Tank Drainfields



🟩 Slight

🟨 Moderate

🟥 Severe

VEGETATION

A healthy plant community contains a variety of species that provide both scenic values and wildlife habitat. In addition, a diversified plant community will survive better after natural catastrophies such as disease, insects and fire. Adequate vegetative cover also serves a vital role in soil stabilization.

Method

The vegetation inventory method used in this study was modified from **Preliminary Forest Habitat Types of Western Montana** (Pfister, Arno, Presby & Kovalchik) which indicates potential vegetation. In addition, existing vegetation (cover type) was mapped.

In order to evaluate vegetative health and possible responses to land uses, the inventory should include past, present, and potential vegetation. Local residents can be an excellent source of information concerning past and present vegetation.

The point of observation, vegetative species, disturbances from insects, fire and disease, and existing land use should be recorded on field maps. Representative observations of vegetation combined with the use of aerial photographs are generally sufficient to map existing vegetation on topographic maps. Remaining questions about existing vegetation should be field checked. The mapping of existing vegetation can also be combined with the inventory of other resources.

Assessing potential vegetation will require more field work, because seedlings, shrubs, forbs, and grasses must be identified. Depending on the variability of the vegetation and topography, sample plots along transportation routes will generally suffice. If the road network is inadequate, the area should be traversed with plots at different elevations, aspects, and slope positions. In order to find key indicator seedlings and undergrowth, plots should be located where the vegetative community has received the least use. The approximate areal extent of the habitat type should be indicated on the topographic map when in the field. The percent cover of each class (trees, undergrowth) and number and species of seedlings occurring on a 0.1 acre circular plot (37 feet in diameter) should be recorded on a standard Forest Service habitat type form.

Measuring the first few plots will be time consuming, but, once the investigator is familiar with the key understory species occurring with each potential tree species, the habitat types can be quickly identified. Information from the plots will supplement the existing vegetation and wildlife habitat inventories. After the plot data have been analyzed the topographic maps and aerial photography can be used to more precisely map the habitat types.

Area Vegetation

Each of the nine habitat types within the study area was rated generally according to its potential for various land uses. The ratings are not direct indications of land capability, but rather translations of habitat type information into a more understandable form for planning.

The resource potential ratings, based on habitat types occurring in eastern Washington and northern Idaho, were modified for the study area. In addition, the habitat types Douglas fir/dwarf huckleberry (DF/Vaca), Douglas fir/twinflower (DF/Libo), and Spruce/twinflower (SP/Libo) are not included in the U. S. Forest Service ratings. Accordingly, field knowledge of the study area was necessary to adjust the ratings to local conditions, and similar adjustments will be necessary to evaluate land use potential for any given habitat type as it exists in different parts of Montana.

No work has previously been published which indicates the habitat type potential for residential use. The residential and recreational use ratings are based on soils, climate, ground water, landforms, susceptibility to damages from insects and disease following disturbance and anticipated tolerance to soil compaction.

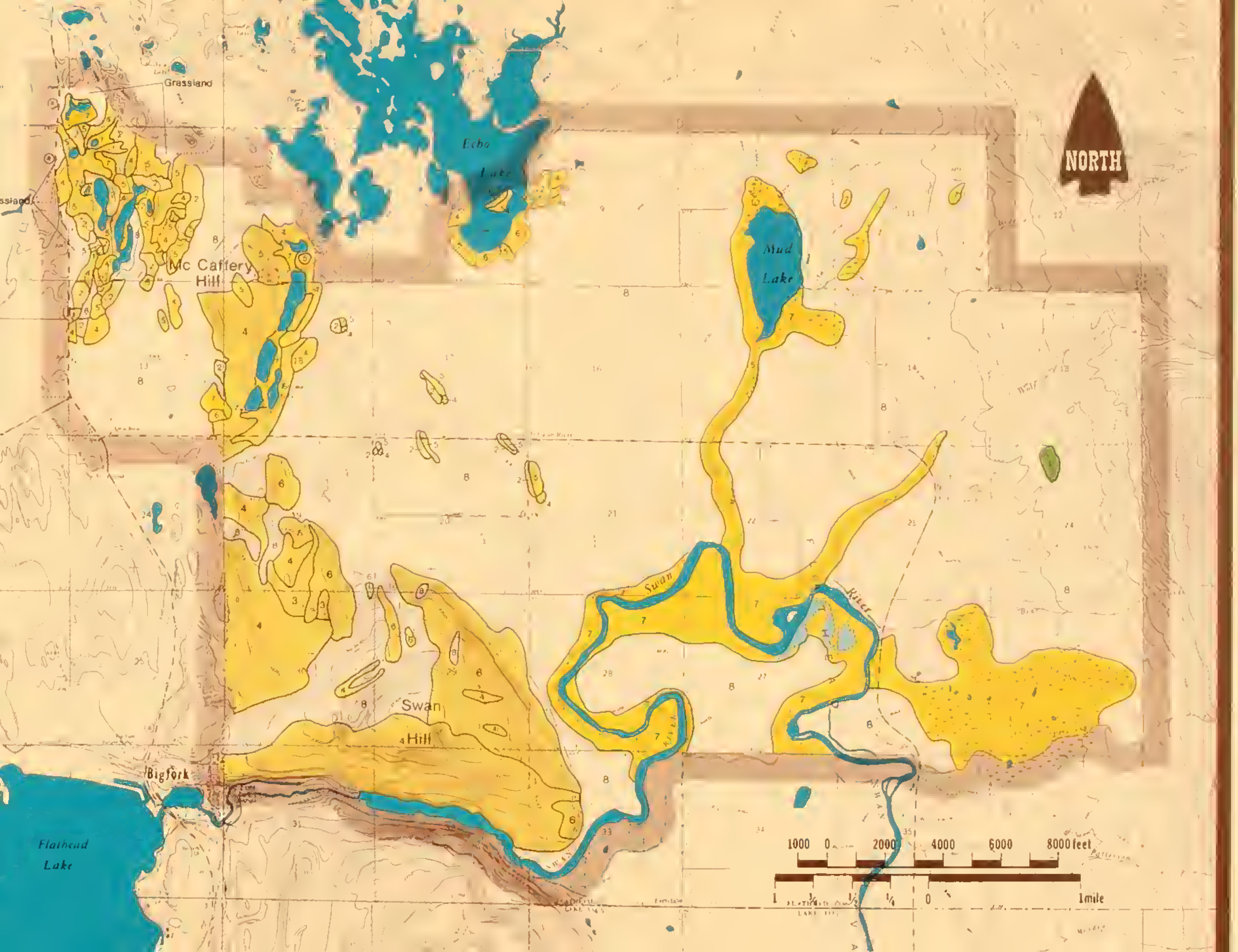
Cover types existing within each habitat type are described in Appendix C.

Broad Land Use Potential Ratings By Habitat Type

	PP/Feid	PP/Syal	DF/Syal	DF/Phma	DF/Vaca	DF/Libo	SP/Libo	GF/Clun
RESIDENTIAL	L	M	M	M	M-H	M	L	M
AGRICULTURE	L	L	L	L	L	L	H	H
TIMBER	M	M	M	H	H	M-H	H	H
WILDLIFE Summer Supply	M	M	M	M	M	M	L	L
Winter Supply	H	M	M	M	M	M	L	L
Winter Demand	H	H	H	H	M	M	H	M
DOMESTIC GRAZING	H	M	M	M	L	L	L	L
WATER (Yield)	L	L	L	L	L	M	M	M
RECREATION (Recovery)	L	M	M	M	M-H	M	L	M

NOTE: Symbols — H-high potential; M-medium potential, and L-low potential

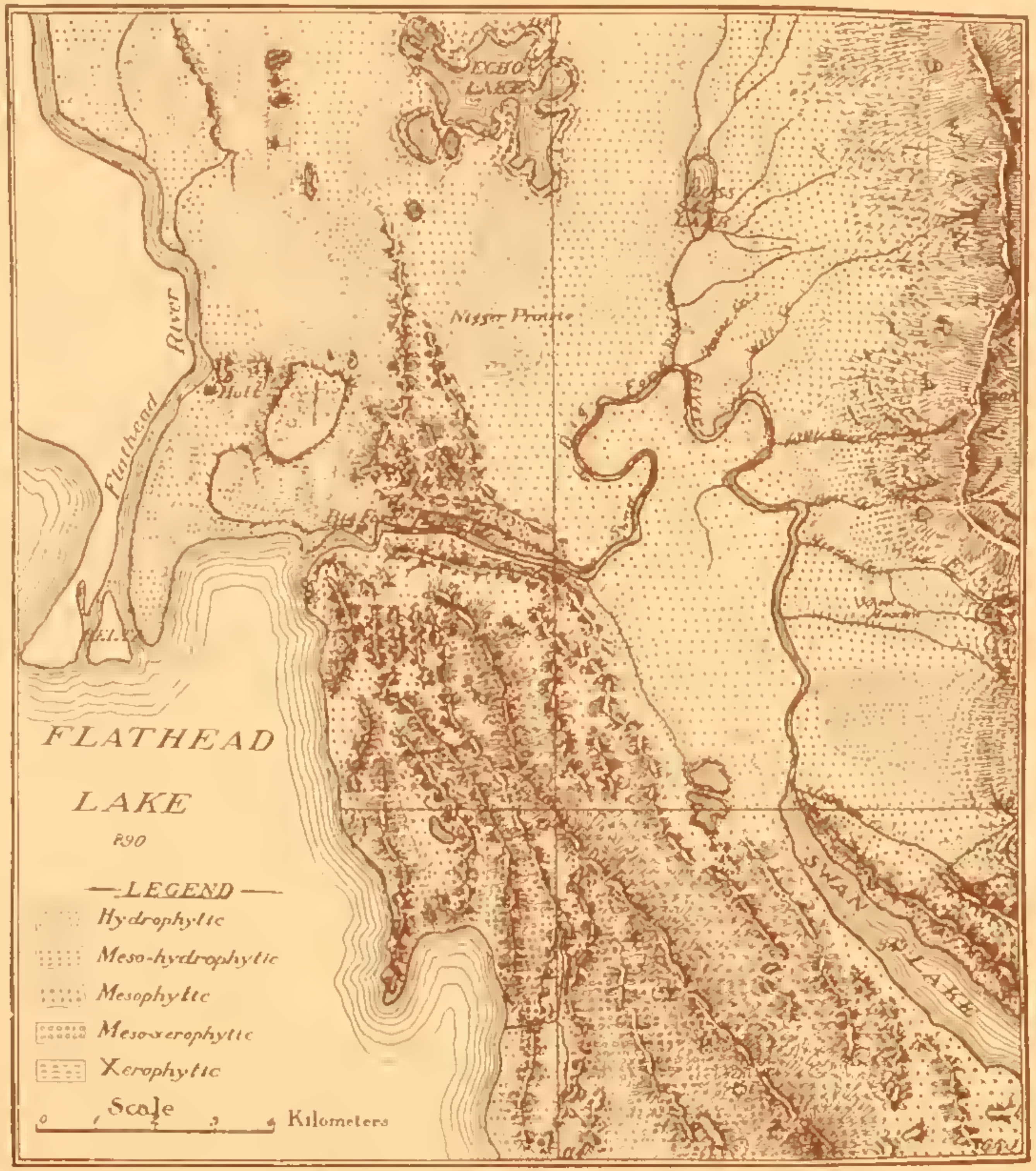
This table was partially derived from Table 4 - "Resource Potential Relative Ratings by Habitat Type," **Management Implications of Habitat Types**, U. S. Forest Service, 1971.



VEGETATION

Habitat Types

1	Ponderosa pine/ idaho fescue (PP/Feid)
2	Ponderosa pine/ snowberry (PP/Syal)
3	Douglas fir/ dwarf huckleberry (DF/Vaca)
4	Douglas fir/snowberry (DF/Syal)
5	Douglas fir/ninebark (DF/Phma)
6	Douglas fir/twinflower (DF/Libo)
7	Spruce/twinflower (S/Libo)
8	Grand fir/ greencup beadlilly (GF/Clun)
9	Relic Plant Community Cedar Swamp



Plant Distribution on the Basis of Moisture Conditions Ranging from Wet (Hydric) to Dry (Xeric), 1905

DENSITY

Vegetative density may provide a general indication of the amount of site disturbance that various land use activities may require. For example, the amount of clearing necessary for residential and road developments is directly proportional to vegetative density.

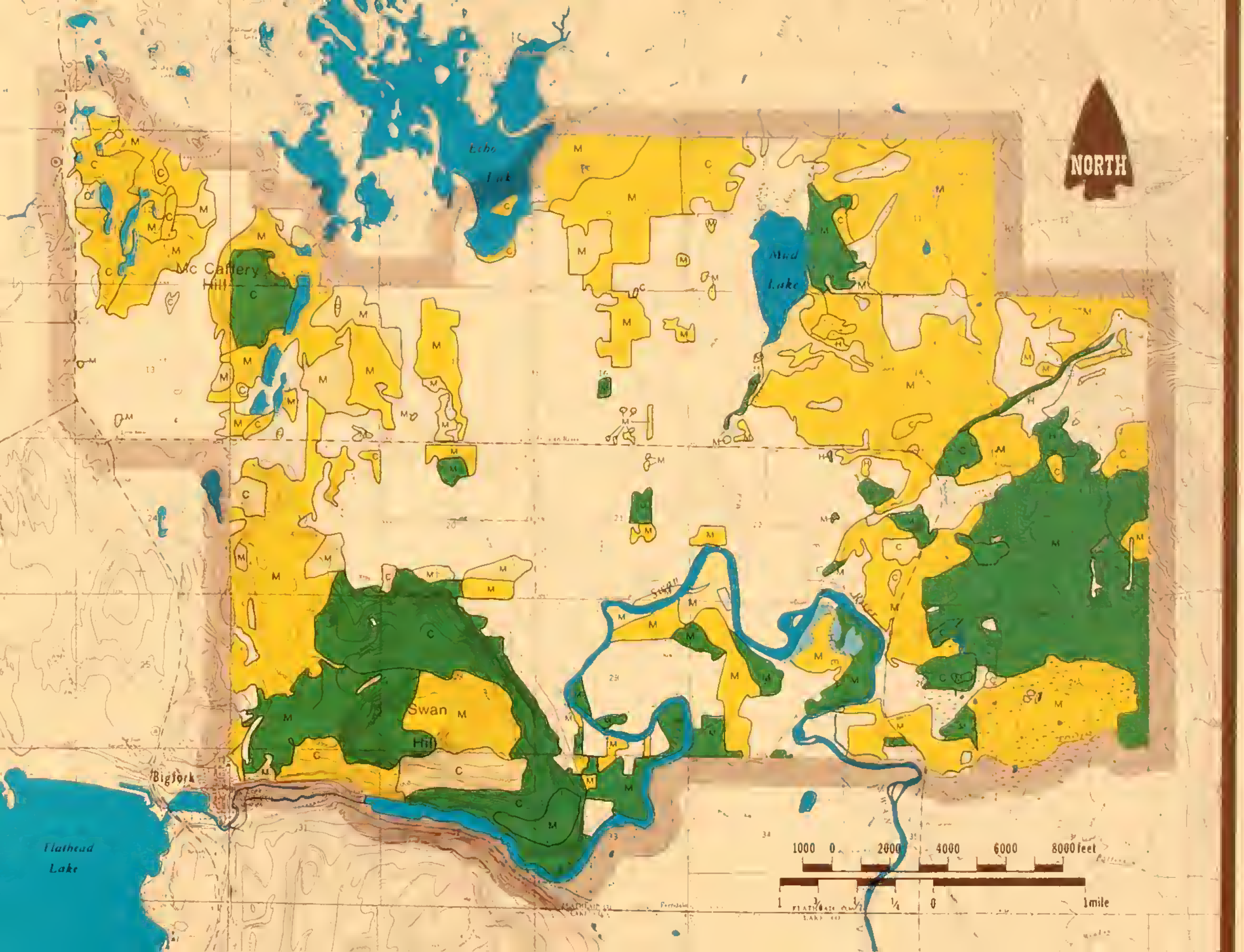
The aesthetic effects of density are also important for planning. While the visual differences between park-like ponderosa pine stands and dense lodgepole pine thickets are obvious, the more subtle considerations such as length of view should also be noted.

Natural vegetation in the study area was classified into three canopy density classes, low (0-40%), medium (40-80%), and high (80-100%), with the aid of a density class overlay designed for use with aerial photographs.

Low Density Ponderosa Pine Stand

High Density Lodgepole Pine Stand

VEGETATION
Density



Percent Crown Cover

☐	Low 0 - 40%
🟨	Medium 40 - 80%
🟩	High 80 - 100%
C	Conifer
H	Hardwood
M	Mixed

WILDLIFE

The demand on fish and wildlife resources has increased dramatically with increases in population and interest in outdoor recreation. Habitat for many species of fish and wildlife in Montana has been destroyed or impaired by housing developments, dam construction, filling in of water bodies, and other factors associated with industrialized society. Areas of fish and wildlife habitat must be identified if development is to be directed away from these important resources.

Method

Aerial photo interpretation for wildlife purposes draws heavily upon the interpretive processes used to describe habitat quality in terms of vegetation, topography, soil, water, and other site factors.

It is feasible to map wildlife habitat using aerial photographs as was done to produce the map on page 49. Resource agencies are able to determine the extent and type of game range from stereoscopic study of the area. Drainage patterns, marshes, lakes, streams and other natural features can easily be identified and delineated on single aerial photographs. However, stereoscopic study is strongly advised to better enable the interpreter to identify subtle changes in the ecosystem, such as the unnatural, rounded and hedged appearance of some browse species in overused big game areas, and to assist in evaluating the height of ground vegetation which might afford protection for small animal species.

A photo interpreter with background in vegetative analysis is able to delineate wildlife habitat types. Although strong conclusions about actual use cannot be made, the interpreter can make inferences based on an understanding of the biological requirements of each animal species and its association with a particular habitat type. The knowledge of greatest importance is that concerning wildlife habits and habitats.

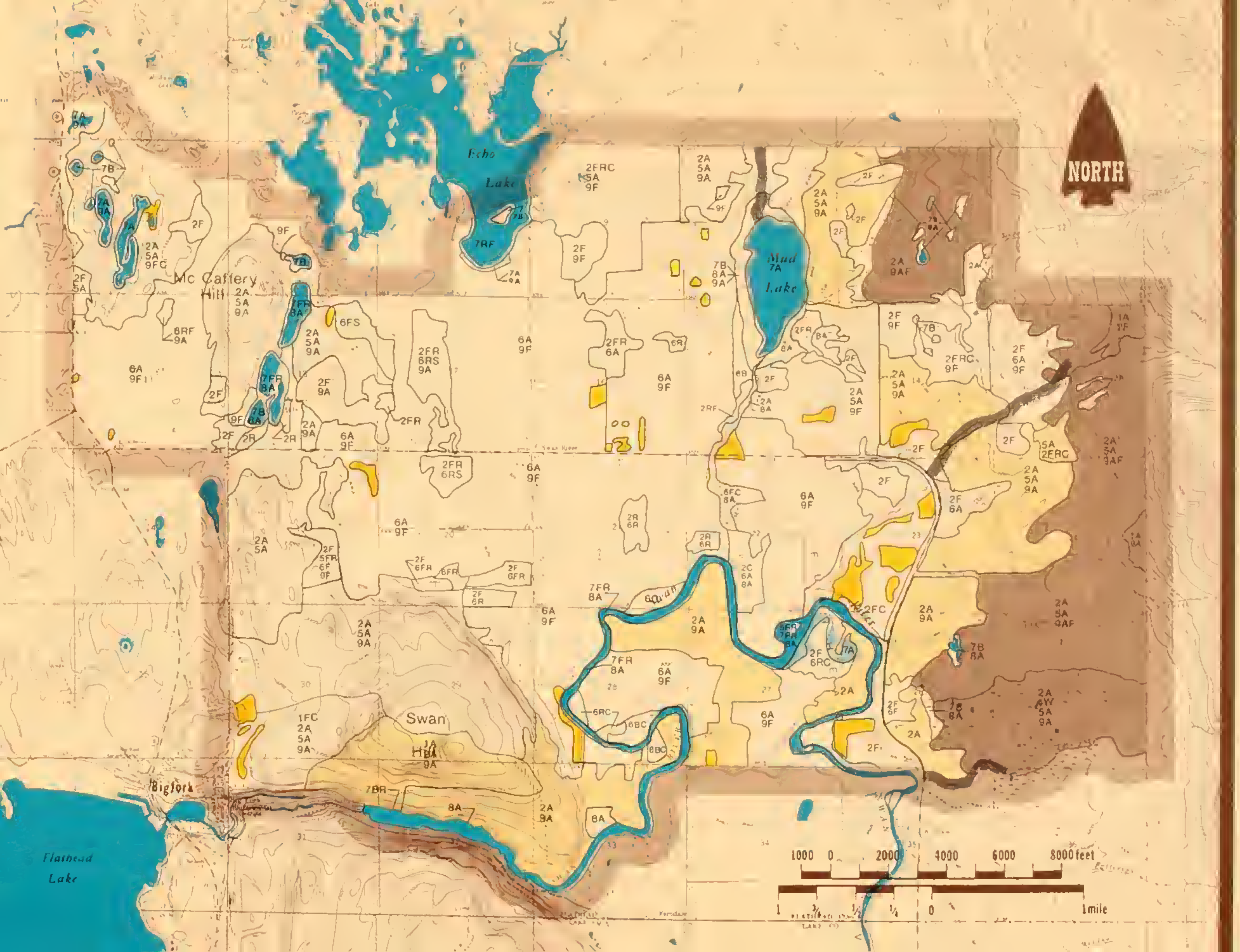
If a greater degree of accuracy is desired than can be obtained from aerial photo predictions, ground reconnaissance work is necessary. The data easiest to gather is simply the presence or absence of a given species. Each habitat type could be field checked to determine presence or absence of animals and animal signs. Most difficult is a census of the various species, which is beyond the scope of general planning studies. While evaluating animal signs, a species list of small animals could be generated from birds and mammals seen.

The methodology for photo-interpretation of wildlife values is quite simple: a) Identification and delineation of habitat types. This should include plant species composition, height and density of vegetation, and physical factors such as rock outcrops, streams and lakes. b) Estimation of the size of the habitat type. Some species of animals require a minimum expanse of a certain habitat type before it will be used. c) Application of wildlife knowledge to habitat types. This last step is understandably the most important.

To simplify mapping of wildlife areas and eliminate excess words and symbols, a code system is used to identify habitat types suitable for a wildlife species. The formation of a code will depend largely upon the objectives of the mapping project, the quality of the photographs, and the land type being investigated.

Because a given habitat type may be used either for all life functions of a species or for a specific activity, it is necessary to identify for each species the possible use of each habitat type.

Much important wildlife information cannot be gathered by remote sensing methods, but the real value of aerial photography lies in the speed of inventory of suitable wildlife areas. The rapid and low cost inventory should allow agencies to spend more time and finances in actual management practices.



WILDLIFE / FISHERIES

- Fishery spawning beds
- ▭ Deer winter range
- ▨ Small Mammal Areas
- ▨ Combined elk and deer winter range

Species

1 Mule deer
2 White-tailed deer
3 Elk
4 Moose
5 Grouse
6 Pheasant
7 Waterfowl
8 Furbearers
9 Predators

Activities

A - all necessary activities
B - breeding
C - cover
F - feeding
T - travel
R - resting
S - seclusion

Area Wildlife

Although the wildlife and fisheries map shows various activities, emphasis is given to wintering areas because deer and elk herds are limited by the quality and quantity of available range during the critical winter season. However, it should be noted that, in any given planning unit, the entire area may be necessary for wildlife. Different parcels are utilized at different times of the year.

The mammals living in and around the study area can be grouped into three categories: large mammals, (e.g. elk, moose, deer and bear); small mammals (e.g. squirrels, mice and rabbits), and fur bearers (e.g., beaver, muskrat, and such predators as coyote).

Bear, moose and elk have a low capability for withstanding human disruption to their natural habitats, but deer can tolerate some disturbances.

There are many different points of view as to the value of small mammals. Homeowners and campers may view them as nuisances; children may regard them as pets; public health officers may fear them as carriers of contagious diseases; and ecologists may consider them a vital link in the natural system. It is certainly true that small mammals form an essential part of food chains necessary to the survival of hawks, owls and most medium-sized mammals.

Birds in the area may be separated into three classes: waterfowl (e.g., ducks, geese and shorebirds); upland game birds (e.g., grouse, pheasant and partridge); and other birds (e.g., open field, timber and marsh species such as woodpeckers, robins, osprey and hawks).

Waterfowl are easily observed and provide pleasure to many people visiting the study area. Limited to a wet habitat, these birds use the marshlands and shoreline for nesting. These aquatic areas must be preserved if water fowl populations are to be perpetuated.

Various land disturbances and losses in agricultural land have reduced the acreage available for nesting, brooding and food-producing for pheasant, partridge and grouse. The future of the upland game birds depends greatly on the management of the wildlands surrounding the developed portions of the study area.

Some of the species which are becoming increasingly rare, such as the pileated woodpecker and osprey, have been driven from their habitat by urbanization and are unable to adapt to a new environment. Many species in the other birds group, notably hawks, herons, owls and woodpeckers, benefit man greatly by reducing harmful rodent and insect populations and consuming weed seeds.

Because of limited existing data and restricted field time, the only fisheries information presented is the location of spawning beds (see map). This information, which was obtained from the Kalispell District Office of the Montana Department of Fish and Game, was checked in the field.

A healthy trout stream contains clean cobbles, creating spawning beds and aquatic insect habitat. Sedimentation and other consequences of poorly planned land development smother spawning beds and destroy conditions necessary for aquatic insects.

It is beyond the scope of most general inventories to produce detailed lists of names and numbers of each species. General knowledge of the fish and wildlife present an understanding of their habitat requirements are more important to planners in order to evaluate their tolerance of disturbances created by man and his activities.

Land use alternatives that are insensitive to scenic values tend to diminish an already limited supply of distinctive visual experiences. The objective of the visual inventory is to identify key values in order to prevent development from impairing the special identity inherent in each area.

Method

The visual inventory technique applied in this study was the corridor landscape method. Existing roads are utilized from which visual limits and other characteristics are recorded on a topographic map.

Before beginning the inventory the following brief description should be augmented with two important publications. **Forest Landscape Description and Inventories — a Basis for Land Planning and Design**, U. S. Forest Service, PSW-49 (Litton), 1968, and **Forest Landscape Management**, U. S. Forest Service, Northern Region, 1972.

The factors affecting the landscape which were considered in this study were distance, observer position, form, space and light.

A conventional way to express distance is to divide the landscape into three planes, foreground (0 to ½ mile); middleground (½ to 5 miles); and background (5 miles to infinity). This provides a convenient isolation of parts for analysis or comparison.

Observer position is a term used to describe the relative location of the observer as above, below or at the same level as the visual objective. Although perception varies with the individual, the way in which man relates to objects is common to us all and partly dependent upon observer position.

Landscape form refers to distant topographic forms such as mountains, hills, buttes and islands. Dominant forms, such as Swan Hill, are more noticeable because of contrast, isolation, size, silhouette and texture or surface variations. The first step toward identifying dominant forms is to examine topographic maps, looking for abrupt contour changes and variations from normal patterns.

Landscape space refers to open features such as meadows, ravines and canyons, which are bounded by mountain slopes, rock walls or vegetation.

An understanding of light and its effects is essential to predict the visual impacts of land use decisions. A given view will vary continually with daily, seasonal and weather changes. The potential for variety, contrast, and uniqueness caused by such characteristics of light as color, distance and direction must be considered along with what is actually seen during the time the inventory is conducted.

Despite variation caused by the observer's movement, certain landscape characteristics are sufficiently constant to form panoramic, feature, enclosed, focal and ephemeral landscape types in the study area. Changes in landscape types were noted along each road corridor inventoried.

Panoramic vistas of the Swan Range with little or no sense of boundary restriction are numerous. Other views are dominated by major or minor features such as Swan Hill or bends in the river, respectively. Landscapes enclosed by trees and other continuous groups of objects were also inventoried, as were those landscape types, such as a roadway along a river, which focus the line of sight on logging cuts or other terminal features. Lastly, the numerous water bodies in the study area often portray ephemeral landscapes such as mirror images. These reflections, wildlife sightings and other transitory landscapes should be noted for planning purposes if they repeatedly occur.

For general planning, the visual corridor is used only as a sample of a larger landscape, and the area beyond the viewed zone should not be ignored.

Area Visual Resources

The visual quality of the Bigfork study area is due to its proximity to the rugged Swan range and Flathead Lake and to its wide variety of water bodies. The distinctive character of the area results from the composite effects of the natural environment and history described thus far.

The aesthetic impacts of the landscape and of new developments on the present setting depend not only upon the natural environment but also on the observer's position, distance and angle of view, lighting, and other purely visual considerations. Key viewpoints, features, settings and overlooks were considered in this context.

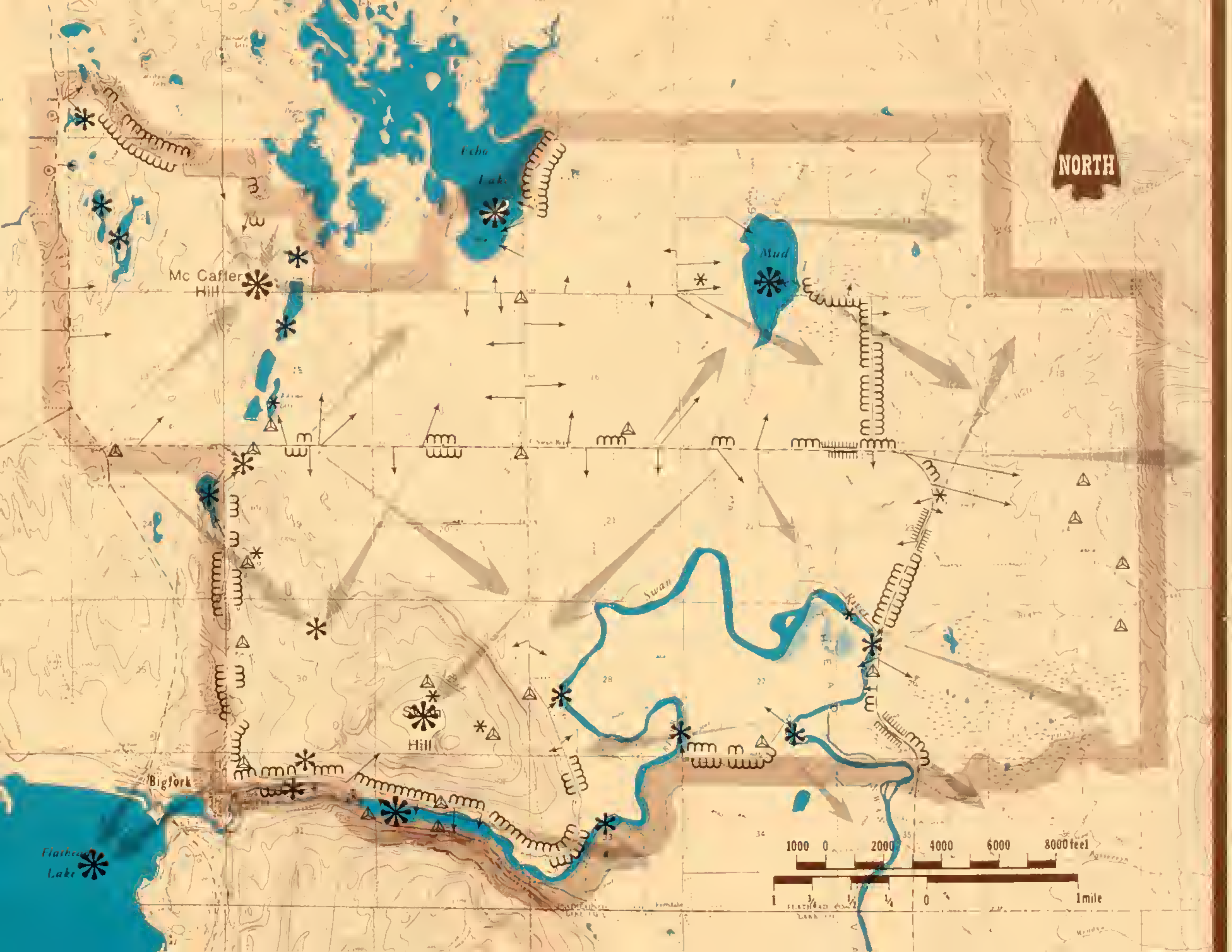
Thus, at Bigfork, Swan Hill is important because it is so near the town that individual trees and rock outcrops can be clearly seen. Visibility of this backdrop is heightened by the westerly exposure to midday and afternoon sunlight. By contrast, the forested hillside to the southeast, which is shaded and more distant, is visually important but much less prominent.

Scenes on the valley floor in the central portion of the study area are mainly open, with panoramic views of the majestic Swan Range. While there is considerable exposure to the sun, wind and sky, the highway corridors are occasionally enclosed by coniferous vegetation. The pothole lakes offer opportunities for reflections, such as mirror images of trees and mountains. In addition, the area contains numerous major and minor landscape features such as rock outcrops, islands and hills which stand out in contrast to their surroundings (see map page 53).

Upstream from the Bigfork dam, the Swan River is a free flowing stream possessing great natural and visual diversity. A wide variety of different landscape types may be viewed from the river corridor. It is in this area that visual intrusions may have the most profound impacts.

The foothills serve mainly as a backdrop for foreground elements including the farmland immediately adjoining the roads. Of special importance as seen from the valley are the skyline silhouettes — the even, bare lines of rocky mountains and the jagged relief of forest slopes.

VISUAL RESOURCES



Enclosure

Focal

Major landscape feature

Minor landscape feature

Potential landscape interest

Problem area

Long view

Short view

RECREATION RESOURCES

Outdoor recreation potential of most areas in Montana is largely a function of natural qualities. Because considerable physical development may directly or indirectly result from recreational use, a detailed inventory should indicate those sites most likely to receive use in relation to natural resource tolerances and limitations.

The recreation inventory is based on two assumptions: (1) that outdoor recreational resonces are limited, and (2) that demands on the resource will increase. This increase is already reflected by the sharp rise in recreational subdivisions and tourist accommodations.

Method

The Bureau of Outdoor Recreation classification system was applied to the region in and around the study area because it provides a general, and yet standard, approach to recreation resource inventory (see map page 55 and Appendix C for description).

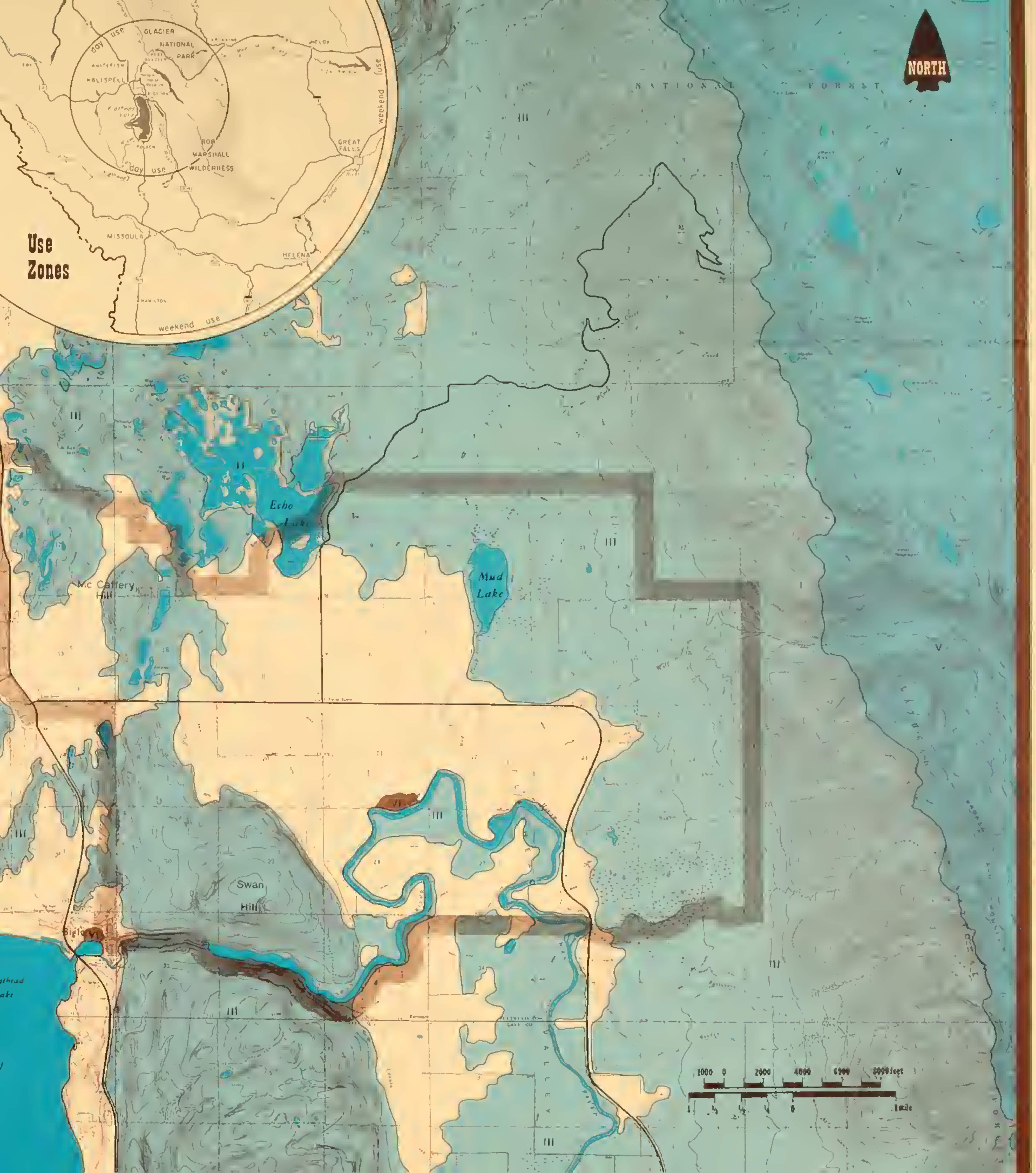
A large portion of the locality is classified as a natural environment area (Class III). As such, recreation potential for activities such as hiking, sightseeing and camping results from complex relationships between landforms, lakes, streams, flora, fauna, climate and accessibility.

The study area provides major access to Jewel Basin (Class V) administered by the U. S. Forest Service. Thus the on-site recreational experience is distinguished from the travel experience, as reflected in the visual resource map (page 53). Certain transportation corridors, such as the main route to Echo Lake and to Jewel Basin beyond, should be viewed as critical visual impact zones.

It is important to identify primary attractions within the region such as Glacier National Park, Flathead Lake and Jewel Basin. Glacier Park attracts over one million visitors annually, many of whom travel through the study area. Secondary nodes of interest such as Echo Lake and Swan River should also be identified.

A general recreation analysis of any given area should be conducted in a regional context. An inset map (page 55) shows population centers within the day-use zone (50 mile radius) and weekend zone (50-150 mile radius).

Most of the recreational use of the area comes from residents within the day-use zone as opposed to non-local tourists who use the area primarily as a transportation route to and from major attraction points. Local recreationists, who may represent any socioeconomic class, exhibit active behavior and great mobility, and they repeatedly return to favorite sites.



RECREATION ANALYSIS

II	Class II General Outdoor Recreation Areas
III	Class III Natural Environment Areas
IV	Class IV Outstanding Natural Areas (Flathead Lake)
V	Class V Primitive Areas
▨	Class VI Historic and Cultural Areas
—	Major recreation access route

U. S. Bureau of Outdoor Recreation Classification System used for this analysis

ANALYSIS

Basis for Integration

Thus far the natural resource inventory has been separated into the major resource fields of geology, climate, hydrology, soils, vegetation, wildlife and visual. This segregation of data is useful for purposes of illustration, but, for a meaningful determination of land capability, interrelationships between resources must be carefully studied. Each area embodies a unique set of interrelationships which should be recognized in the field and analyzed with available data in the office.

For example, in the study area the rising level of pothole lakes was compared with the water levels shown on the topographic map. Local residents observed that the potholes undergo cyclic high and low levels, but that the present rise was due to additional influences. Geologic studies indicated that the lakes receive their water from aquifers which are recharged at the base of the Swan Mountains. Photographic comparisons over time revealed that considerable vegetation had been removed from the Swan Range foothill landform, including the recharge areas. The resulting increased spring runoff percolated into the ground water, causing a rise in water level in late summer. The ecological principle that everything affects everything else must be recognized when determining cause and effect relationships. In this case, vegetative manipulation is partially responsible for higher water levels.

The general analysis of natural resource data for broad level planning necessarily results in the oversimplification of a complex ecosystem. However, the consideration of other ecological concepts, such as ecological niches, carrying capacity, limiting factors, and ecosystem diversity, stability and specialization, is implied in the analysis.

The early determination that hydrology was the key resource in the study area was helpful in arranging priorities for further inventory and analysis. Key resource values are highly variable and can only be determined by an on-the-ground appraisal.

As a general illustration of resource interrelationships, topography is the result of geomorphic processes such as mountain building, water movement or mass wasting. The soils are a product of vegetation, climate and geologic material and processes over a period of time. Hydrologic patterns are closely tied to geologic and climatic conditions. Vegetation is an expression of genetic adaptability to soils, topography (slope and aspect), climate and hydrology. Wildlife, in turn, depends on the quantity, distribution and diversity of vegetation. All of these resources interact to form the natural and visual qualities of the landscape.

Because of these interrelationships between resources, a true multi-disciplinary inventory approach is needed in which all of the specialists employed spend some time in the field together. In this way coordination problems can be minimized and time and money saved in the subsequent analysis of data.

Environmental Matrix

The analysis of natural resource data for planning must include an assessment of environmental changes associated with various developmental activities. The first step is to determine the environmental requirements of each type of activity. These requirements are difficult to establish, since land uses vary in their inherent needs and in the monetary and environmental costs of overcoming natural limitations. For example, buildings can be placed in earthquake hazard areas but only with greatly increased risks and construction costs.

Secondly, the types of activities must be interpreted in terms of direct actions on the environment, which are highly variable. Their determination depends on an understanding of the physical changes involved. The degree of impact depends on the particular site, the type, scale and design of development, and the success in matching activities to land capabilities.

Lastly, an understanding of ecological interrelationships must become the basis for controlling developmental impacts.

Any planning area has only a limited number of sites with the suitable combination of slope, soils, vegetation, climate, and absence of natural hazards. These sites should be put to those uses most in need of their particular set of resource characteristics.

A simple itemization of environmental requirements and direct actions associated with different types of activities is helpful to illustrate potential environmental impacts.

The matrix on the following page visually demonstrates relationships between the three important elements of activities, requirements and actions. The information in the matrix was obtained from evaluations of many resource specialists, responses of citizens to a questionnaire, resource inventory data of the study area, and other land capability studies.

The matrix can be used as a guide for identifying the need for more detailed information. The relationships indicated by the matrix also provide a starting point for delineating broad capability units. The more detailed matrix (pages 62, 63) indicates compatibility between land uses and resource factors.

Environmental Matrix

TYPE OF ACTIVITY	ENVIRONMENTAL REQUIREMENTS														DIRECT ACTIONS														
	Absence of Hazards	Nearly Level Terrain	Easy Excavation	High Surface Water Quality	High Ground Water Quality	Good Soil Drainage	Septic Tank Capability	Stable Foundation Conditions	Productive Soils	Favorable Micro-Climate	Presence of Natural Vegetation	Presence of Wildlife	Presence of Scenic Views	Presence of Historic Values	Excavation, Cutting	Earthmoving, Filling	Vegetation Removal	Paving	Building	Utilities	Fences	Introduction of Exotic Plants	Biological Waste Products	Chemical Waste Products	Tilling	Drainage Ditches	Irrigation	Fertilization	Fire Suppression
High Density Housing	●	●	●			●		●		●			●		●	●	●	●	●	●	●	●	●	●		●	●	●	●
Medium Density Housing	●	●	●	●	●	●	●	●		●			●		●	●	●	●	●	●	●	●	●	●		●	●	●	●
Low Density Housing	●			●	●	●	●	●		●			●		●	●	●	●	●	●	●	●	●	●		●	●	●	●
Intensive Recreation	●	●	●	●	●	●	●	●		●	●	●	●		●	●	●	●	●	●	●	●	●	●		●	●	●	●
Extensive Recreation				●						●	●	●	●	●									●						●
Roads	●	●	●			●		●							●	●	●	●			●					●		●	
Logging	●		●						●		●				●	●	●												●
Agriculture				●	●	●			●							●	●				●	●			●		●	●	●
Grazing				●	●	●			●		●						●				●	●	●		●			●	●

The matrix portrays the physical and qualitative attributes and direct actions normally associated with common types of development.

LAND CAPABILITY

The determination of basic capabilities of the land to tolerate developmental disturbances without long range serious consequences to environmental quality and productivity begins with a synthesis of information on geology, climate, hydrology, soils and vegetation. The key to the identification of the capability classes shown on the adjacent map was the stratification of the study area into broad homogeneous units based on geology, climate, landforms, hydrology, slope, soils and vegetation.

If possible, the geomorphic unit should be the analytical basis for determining broad land capability. A geomorphic unit contains recurring patterns of landforms, soils, vegetation and drainage with uniformity in both geologic origin and active erosional and hydrologic processes. However, the small size of the study area and the slight variation in land-forming processes precluded the use of geomorphic units for this classification.

Although the number and sequence of steps will vary with each inventory, the procedures used in this study for stratification are as follows:

1. Place both basic and interpretive data on transparent overlays.
2. Begin with the geology overlays with emphasis on the geologic limitations of each landform.
3. Compare climate with landforms to establish preliminary classes based on precipitation. (Use average precipitation if climatic data is inadequate.)
4. Assess relationships between climate and hydrology, and again form rough capability classes if sufficient climatic data exists.
5. Compare hydrology with landforms, noting the occurrence of hydrologic limitations within each landform.

This stratification of geology, climate and hydrology by landform is the basis for determining broad capability classes. The next step is to:

6. Determine whether uniform slope classes occur by landform.

If these procedures have not resulted in recognizable capability units, possibly because of uniformity in natural conditions, a further stratification will be required using soils and vegetation data.

7. Compare basic and interpretive soils data with vegetation to identify patterns such as the occurrence of certain plant species on highly erosive soils.
8. Compare soils with hydrology and landforms, noting soils limitations by landform.

Patterns and interrelationships should now be evident as an adequate basis for determining land capability classes.

The major criteria for land capability are risk to life and property from natural hazards and maintenance of environmental quality. The emphasis thus far has been on the identification of physical limitations, which must next be related to present and potential land uses (see matrix page 57). The most critical land use will be that activity which is increasing and high in both environmental requirements and direct actions, such as residential use in the study area. Based on these criteria water quality, available ground water, slope limitations and erosion potential are important considerations for land capability.

After land capability has been broadly defined according to physical criteria, the classes should be tempered in accordance with planning goals. Such goals should indicate acceptable levels of modification, ranging from no development to intensive development, within various parts of the planning area.

Four broad land capability classes are shown on the adjacent map for general planning purposes and are briefly defined as follows:

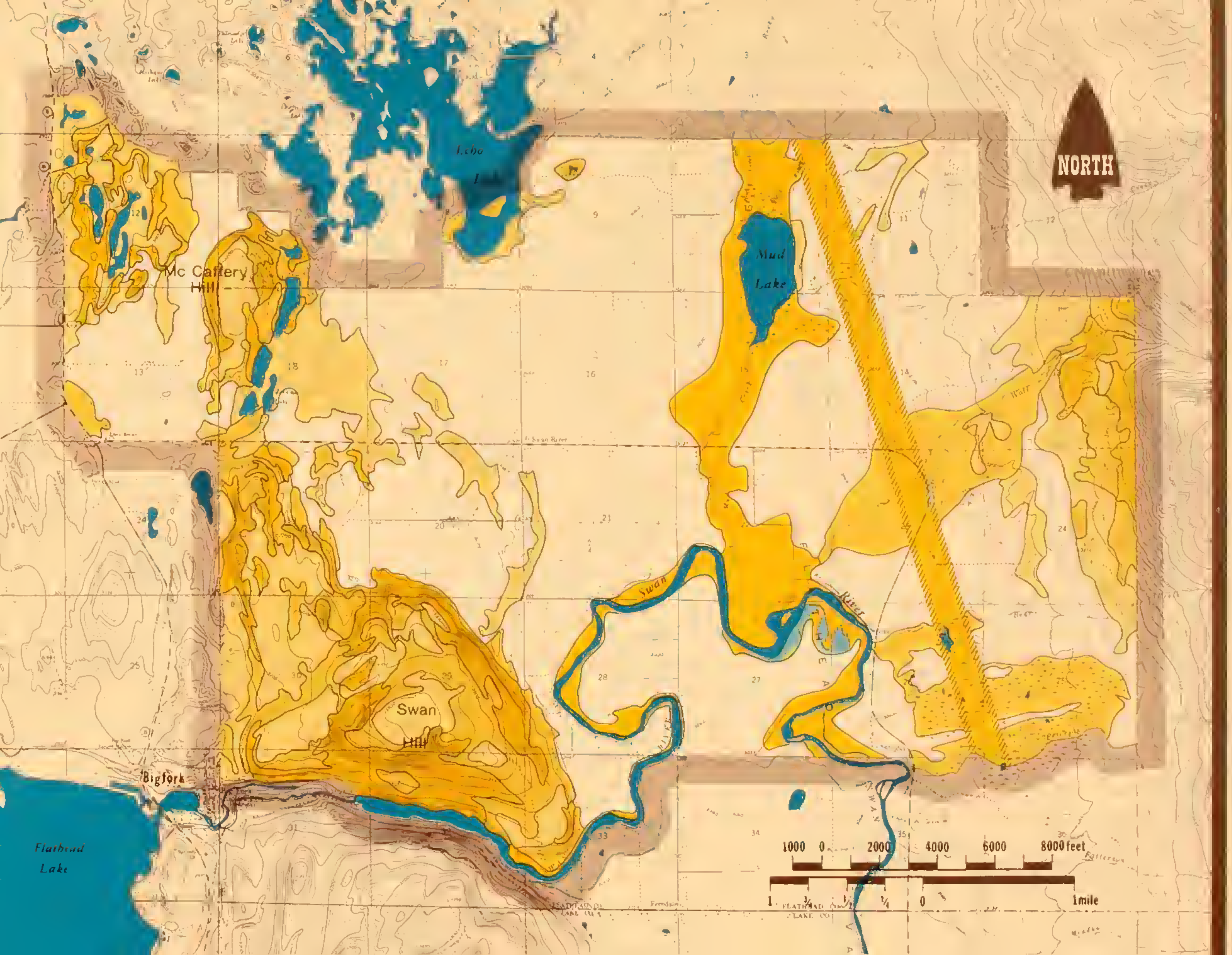
I Severe Limitations — Soils and landforms have high disturbance hazard characteristics. These areas include flood plains, landslide areas, fault zones, and steep slopes of 25% or more with high erosion and runoff risk and no potential for structural development.

II Moderate Limitations — These lands have moderate disturbance hazard characteristics. Slopes range from 15 to 25%, and vegetative removal may cause accelerated erosion and runoff. Some landforms, such as the alluvial fan and swamp, have a high seasonal water table subject to pollution.

III Some Limitations — Soils and landforms have low erosion and runoff potential. Slopes are 8 to 15% on the kame and kettle, Swan Range foothill and McCaffrey and Swan Hill landforms. Problems include shallow soils, limited water supply, fluctuating lake levels and potential for surface and ground water pollution. There is some potential for low density housing.

IV Few Limitations — These lands have low disturbance hazard characteristics with few limitations that restrict use. Such areas include portions of the valley floor and kame and kettle landforms where slopes range from 0 to 8%. Water is available in good quantitites, and soils are generally suitable for residential, road and on-site sewage disposal uses.

LAND CAPABILITY



- ▨ Class I
  Severe limitations
- ▨ Class II
  Moderate limitations
- ▨ Class III
  Some limitations
- ☐ Class IV
  Few limitations
- ▨ Approximate Fault Zone

Note:
Class boundaries are drawn only to a 10 acre minimum.

CELLULAR ANALYSIS

Of equal importance to determining physical land capability in land use planning is the land's suitability for different uses without detriment to the quality of the environment. Components of the quality of life include open space, aesthetics, clean air and water, wildlife and fisheries, recreational opportunities, and historical and cultural features. Application of these considerations to planning is difficult because of the wide diversity of public opinion and the need for value judgements as to what constitutes environmental quality.

The determination of broad capability and suitability is adequate for county or state-level planning, but a priority area of smaller size requires a more detailed analysis of data. The alternatives considered were single-factor analysis, biophysical unit analysis, polygon mapping, and cellular analysis.

Single factor analysis involves the use of several maps, each of which portrays a different characteristic such as depth to water table. Overlays are then superimposed, and areas suitable for a specified use, such as a sanitary landfill, appear as "windows" on the overlays. This method is more appropriate for locating areas suitable for a particular use rather than for general planning.

The biophysical unit is the least arbitrary for determining land capability, because it is uniform in basic elements of the ecosystem, soils, slope, existing vegetation and potential vegetation. This method is quite detailed, requires considerable data, and is suitable for site-level inventories.

Polygon (line) mapping involves the use of original data as input and lines of equal value, similar to a contour map, as output. Advantages include reliability, since original data appears as output, and flexibility, since scale changes and comparisons can be rapidly made.

Cellular (grid) analysis was chosen in this instance partly because computer technology was unavailable for the study. The analysis began with original resource data to form the composite shown on the opposite page.

The cell is square and of constant size, which aids in analysis. The cells must be identified by numerical coordinates which describe relative location. For purposes of illustration only the cells on the opposite page were referenced by section lines. Use of the Universal Transverse Mercator grid system (UTM) is recommended for geographic reference because it is uniform, widely available and compatible with satellite photography.

If the grid cell is chosen as the basic unit for data acquisition, processing, storage, analysis and display, an important decision will concern the size of the cell. Cell size will depend on the mapping accuracy of the data and the desired mapping scale for planning. Smaller cells can be used if computer technology is available to handle large quantities of data. Larger cells result in lower data collection and analysis costs, which can be substantial if manual processes are used.

A 10-acre cell size was employed in this study after an analysis of all overlays indicated that size to be most compatible with data accuracy (input) and maintenance of data detail (output). The Northwest quarter of the Southeast quarter of Section 28, Township 27 North, Range 19 West, was chosen to demonstrate cellular analysis, because it contains diverse topography ranging from flood plains to foothills. This 40-acre tract was divided into four equal size cells, and each was rated according to capability and suitability.

Cells were generally evaluated according to the most limiting resource feature. For example, the potential for structural development is low if any portion of the cell contains flood plain (capability factor) or endangered wildlife species (suitability factor). Most cells are not as clearly defined and require closer analysis.

The detailed analysis begins with acceptable levels of physical modification derived partly from planning goals. These are related to broad capability classes in order to reduce the number of uses to be considered in each cell.

A land use under a desired level of modification is first taken from the above table. The compatibility of each capability and suitability factor within the cell for the particular land use is determined (see matrix, pages 62, 63).

Because of data limitations no attempt was made in this study to rank the relative importance of resource features. Each feature is given equal weight, and the total number of incompatible ratings portrays the capability of the cell. For example, the following ranges were used to determine the capability of the cells on the following page: high - 0 to 5, Medium - 6 to 10 and Low - 11+. The same process is repeated for quality of life factors. Each cell is thus rated as to both suitability and capability for each of the land uses that are appropriate for that cell according to its broad capability class and the level of modification.

The above procedures are suggested only as a starting point for further refinement. As state and local planners become increasingly familiar with the advantages of efficient handling or large quantities of data through both polygon and cellular mapping, it is conceivable that the necessary computer technology will soon become available at both levels of government.

LAND USES BASED ON CAPABILITY AND LEVEL OF MODIFICATION

LEVELS OF MODIFICATION	CAPABILITY CLASSES			
	I	II	III	IV
1. **Low Development** Natural environment, maximum ecosystem diversity and stability	R_E	R_E	R_E,R_I	R_E,R_I
2. **Medium Development** Activities associated with roads, low density housing, agriculture and logging.	R_E,G	R_E,G, L	R,R_E,R_I A,G,L	R,R_E,R_I A,G,L
3. **High Development** Activities associated with high density housing and industry.	R_E,G	R,R_E,R_I A,G,L	R,R_E,R_I A,G,L	R,R_E,R_I I,A,G,L

R - residential

R_E - recreation, extensive

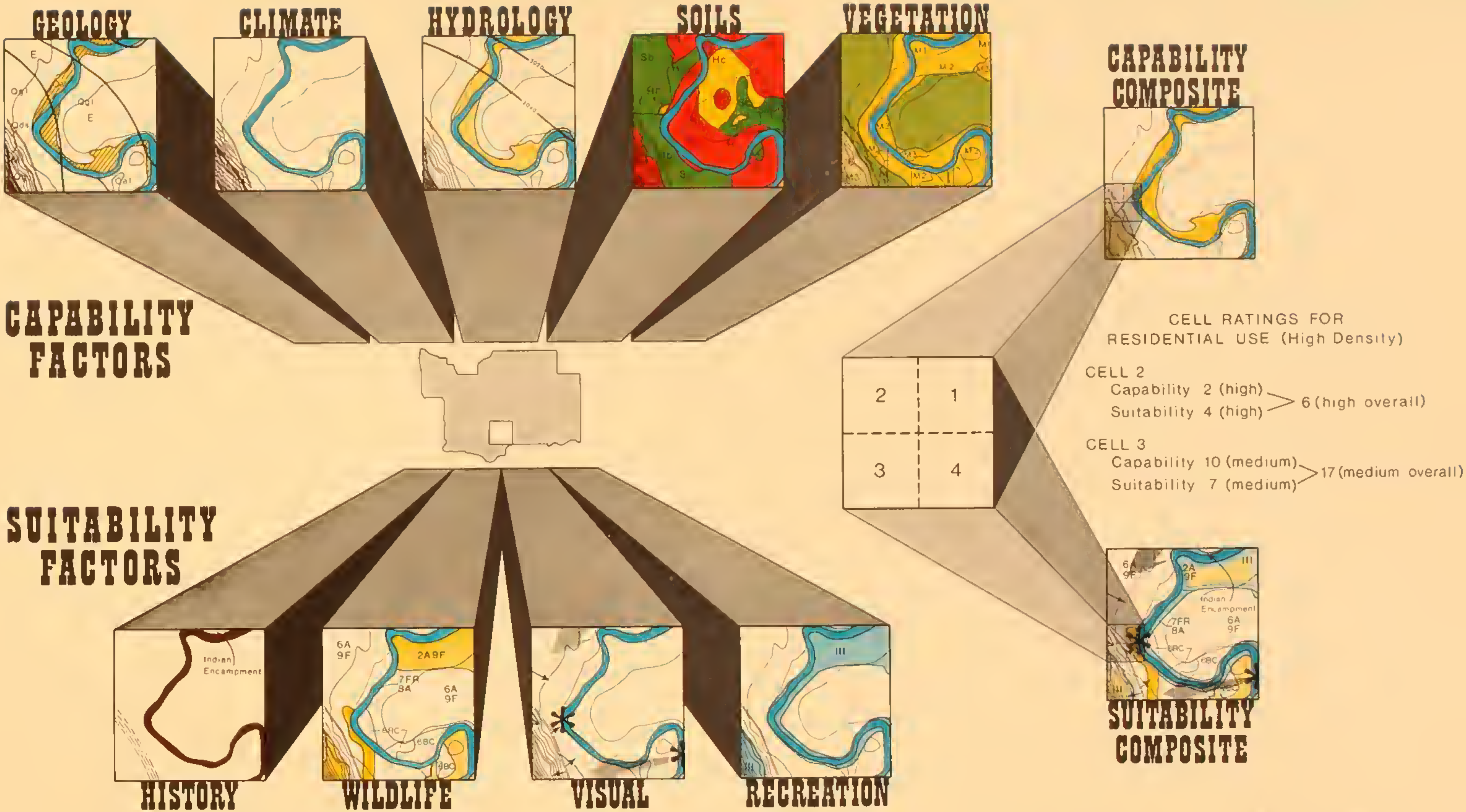
R_I - recreation, intensive

I - industry

A - agriculture

G - grazing

L - logging



CELL RATINGS FOR RESIDENTIAL USE (High Density)

CELL 2
Capability 2 (high)
Suitability 4 (high)
> 6 (high overall)

CELL 3
Capability 10 (medium)
Suitability 7 (medium)
> 17 (medium overall)

Resource features within Section 28, T27N, R19W, are reproduced above from maps appearing on preceding pages with the exceptions of geology and vegetation, which represent composites of earlier maps. The soils map is a reproduction of the residential limitations map (page 41), and the capability composite is duplicated from the land capability map (page 59).

Because cells 1 and 4 within the NW ¼ of the SE ¼ of Section 28 contain flood plain they are omitted from detailed analysis.

Cells 2 and 3 are evaluated for only those capability and suitability factors existing within each cell. Otherwise, "no relation" is indicated (see matrix pages 62-63). The cell ratings are based on relative compatibility for high density residential use.

COMPATIBILITY MATRIX

CAPABILITY FACTORS (C)
(Physical)

⊖ No Relation

● Incompatible

Activities	Landslides	Faults	Bedrock Exposure	Temperature Inversions	Strong Winds	Storm Paths	Heavy Rains	Heavy Persistent Snow Pack	Climatic Exposure	Aquifers - Pollution Susceptibility	Water Availability	Aquifer Recharge Areas	High Water Table	High Runoff Potential	Flood Plain	High Erosion Potential	Shallow Soils	Slopes 8%	Slow Permeability	Vegetative Habitat Types	High Vegetative Density	Presence of Natural Vegetation	TOTAL
CELL 2																							
RESIDENTIAL High Density	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	●	⊖	●	⊖	⊖	⊖	⊖	2
Low Density	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	●	⊖	●	⊖	⊖	⊖	⊖	2
RECREATION Intensive	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	●	⊖	●	⊖	⊖	⊖	⊖	2
Extensive	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	0
ROADS	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	●	⊖	⊖	⊖	⊖	⊖	⊖	1
CELL 3																							
RESIDENTIAL High Density	⊖	⊖	●	⊖	⊖	⊖	⊖	⊖	⊖	●	●	●	⊖	●	⊖	●	●	●	⊖	⊖	●	●	10
Low Density	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	●	●	⊖	⊖	●	⊖	●	●	●	⊖	⊖	⊖	⊖	6
RECREATION Intensive	⊖	⊖	●	⊖	⊖	⊖	⊖	⊖	⊖	●	●	⊖	⊖	●	⊖	●	●	●	⊖	⊖	●	●	9
Extensive	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	0
ROADS	⊖	⊖	●	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	●	⊖	●	●	●	⊖	⊖	●	●	7

For purposes of illustration, only some of the activities derived from the capability class - level of modification table (page 60) are indicated in the vertical column.

SUITABILITY FACTORS (S)

(Quality of Life)

⊖ No Relation

● Incompatible

Activities	Natural Features of Unique Scenic, Scientific or Educational Value	Watersheds for Stream Quality Protection	Relic Plant Communities	Rare and Endangered Species	Key Fishery Habitat (e.g. spawning beds)	Big Game Winter Range	Migratory Routes	Wildlife Habitat for other Necessary Activities	Major Visual Features	Minor Visual Features	Critical Visual Corridors	Visual Problem Areas	Outdoor Recreation Class	Major Access Route	Features of Historical Value	Water Quality	Air Quality	Preservation of Open Space	Agricultural Land	TOTAL	GRAND TOTAL (C+S)
CELL 2 RESIDENTIAL High Density	⊖	⊖	⊖	⊖	⊖	⊖	⊖	●	⊖	⊖	⊖	⊖	⊖	⊖	●	⊖	⊖	●	●	4	6
Low Density	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	●	●	2	4
RECREATION Intensive	⊖	⊖	⊖	⊖	⊖	⊖	⊖	●	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	●	●	3	5
Extensive	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	0	0
ROADS	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	●	1	2
CELL 3																					
RESIDENTIAL High Density	⊖	⊖	⊖	⊖	⊖	●	●	⊖	⊖	⊖	⊖	●	●	⊖	●	●	⊖	●	⊖	7	17
Low Density	⊖	⊖	⊖	⊖	⊖	●	●	⊖	⊖	⊖	⊖	⊖	●	⊖	⊖	●	⊖	●	⊖	5	11
RECREATION Intensive	⊖	⊖	⊖	⊖	⊖	●	●	⊖	⊖	⊖	⊖	●	●	⊖	⊖	●	⊖	●	⊖	6	15
Extensive	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	0	0
ROADS	⊖	⊖	⊖	⊖	⊖	●	●	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	2	9

REMOTE SENSING

The amount of information that can be obtained from remote sensing depends on the purpose and quality of the photography. The informational objectives will determine the scale, film type and time of photography.

Single vertical photographs are usable for field purposes, but more information can be obtained by observing the 3 dimensional model from two overlapping photographs.

Depending upon film type, photo quality and scale, a resource specialist with knowledge of aerial photogrammetry using tone, texture, pattern, shape and location can identify gross land forms, geological formations, soil types, hydrological patterns, vegetation, land use and cultural features.

Although considerable information can be derived from normal black and white photographs, color film, especially false color infrared, will clearly show features that are only subtly visible on black and white. A resource specialist can be quickly trained to recognize the signatures on infrared transparencies relevant to his field. More training time is required for non-specialists, but signatures for level II land uses and water pollution can be readily learned.

False color infrared film records the wavelength of .5 to .9 microns (from visible light to infrared). The green color of healthy vegetation appears red, and stressed or diseased vegetation registers as blue-green. Natural colors of objects in some cases make ordinary color film superior to infrared transparancies. However, color differentiation decreases with increases in altitude, especially above 30,000 feet, because of atmospheric haze.

Because shaded areas cannot be interpreted, it is essential that an area be photographed with infrared when the sun is at or near its highest point. Although infrared will penetrate light haze, satisfactory results require clear weather for cloud cover will block out ground features.

A few areas in Montana have been photographed using large scale infrared, but the greatest infrared film coverage has been done by the National Aeronautics and Space Administration with high flying U-2 aircraft and satellites.

Even if the planning area is small, available photographs of various scales should be obtained. Smaller scale photography is helpful for delineating priority areas and examining external influences. The recently taken photo on page 65 is convenient for broad level analysis since the entire study area is covered and enough surrounding land included to disclose external features.

The interpretative value of photography varies with scale. For example, geologic and hydrologic inventories can be conducted better and more quickly with small scale U-2 infrared photographs (i.e., 1:125,000). Hardwoods and conifers are also more easily differentiated using small scale infrared. Conversely, soils mapping and detailed vegetative inventory require larger scaled photography (i.e., 1:12,000). Tree species and in some cases shrub and grass identification can be achieved using large scale infrared photographs with a minimal knowledge of plants on the ground.

The optimum scale of infrared will depend upon time available for interpretation, finances and inventory goals. If general interpretations are desired, a compromise of the optimum scales for each resource may be necessary to determine an all-purpose scale suitable for land use planning.

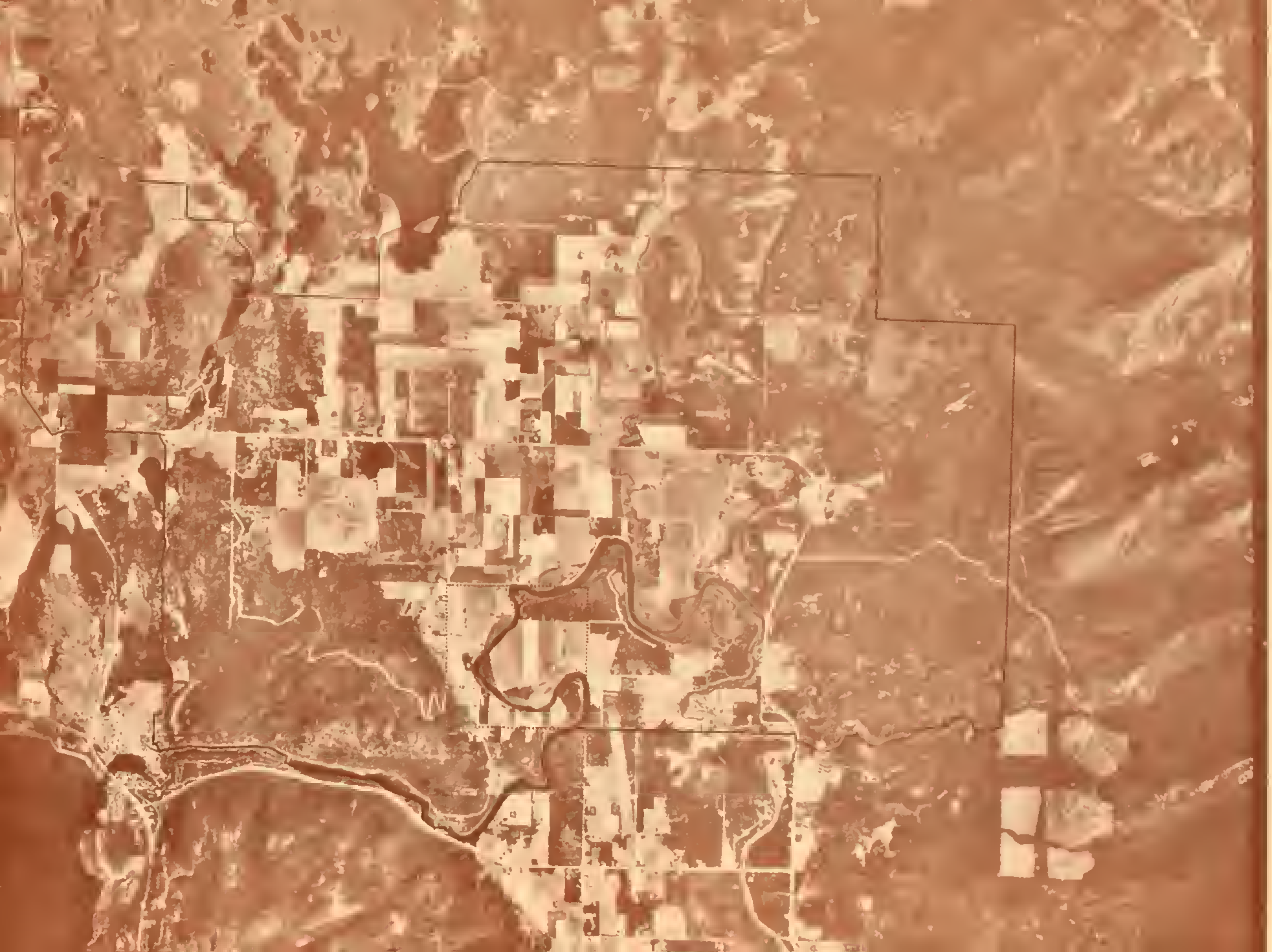
Good quality infrared photographs can be taken at a large scale and still meet or exceed the interpretive value of small scale black and white photographs

Guidelines for Aerial Surveys

Description of Task	Film Type	Season	Scale
General Geology	1. Color IR 2. Multispectral 3. Slar 4. Pan	Spring, summer fall, no snow	1:20,000-1:125,000
General Hydrology	1. Color IR 2. Thermal	Late summer, early fall	1:12,000-1:125,000
Flood Plains	1. Color IR 2. Pan	Early spring, fall	1:12,000-1:24,000
Water Pollution	1. Multispectral 2. Color IR 3. Thermal IR	All seasons	1:4,800-1:8,000
General Soils	1. Color 2. Color IR	Late summer, fall	1:8,000-1:24,000
Agricultural Soils	Color	Spring or fall, after plowing	1:4,800-1:8,000
Mixed Forest Stands	Color IR	Late spring, fall	1:12,000-1:125,000
Range Vegetation	Color	Summer	1:600-1:2,400
Insect Damages	Color IR	Spring, summer	1:600-1:5,000
Plant Diseases	Color IR	Spring, summer	1:1,200-1:7,200
Wildlife	1. Color IR 2. Color	Spring, summer	1:6,000-1:40,000
Fisheries	1. Color IR 2. Thermal IR	Periods of low water	1:1,000-1:10,000
Urban Planning	1. Pan 2. Color IR	Late fall, winter	1:4,800-1:9,600
Recreational Surveys	Color Negative	Late fall, winter	1:5,000-1:12,000
Archeological Explorations	Color IR	Fall, winter	1:2,400-1:20,000

NOTE: Some of the information in this table was obtained from **Photointerpretation for Land Manager,** by T. Eugene Avery, Eastman Kodak Co., Rochester, N.Y., 1970, page 19.

AERIAL VIEW



Study Area boundary

○ Swan River

† Little Brown Church

⌐ Section 28 (Selected for detailed analysis)

Scale: 1 mile

Photo date: June 1971

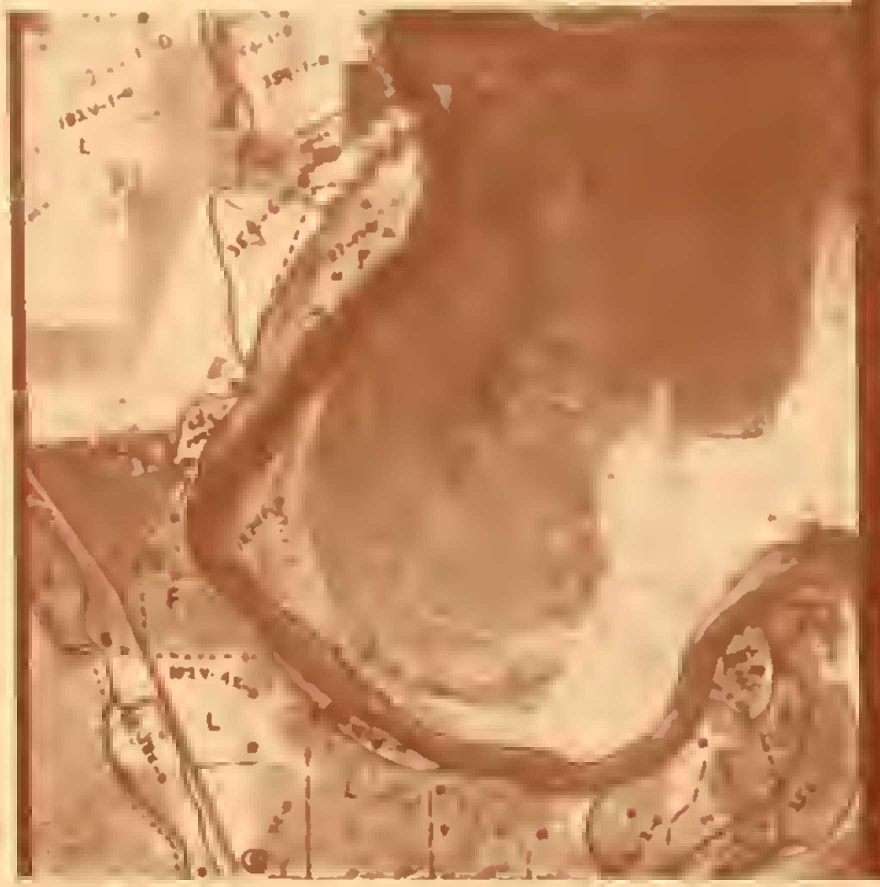
Source: U.S. Forest Service

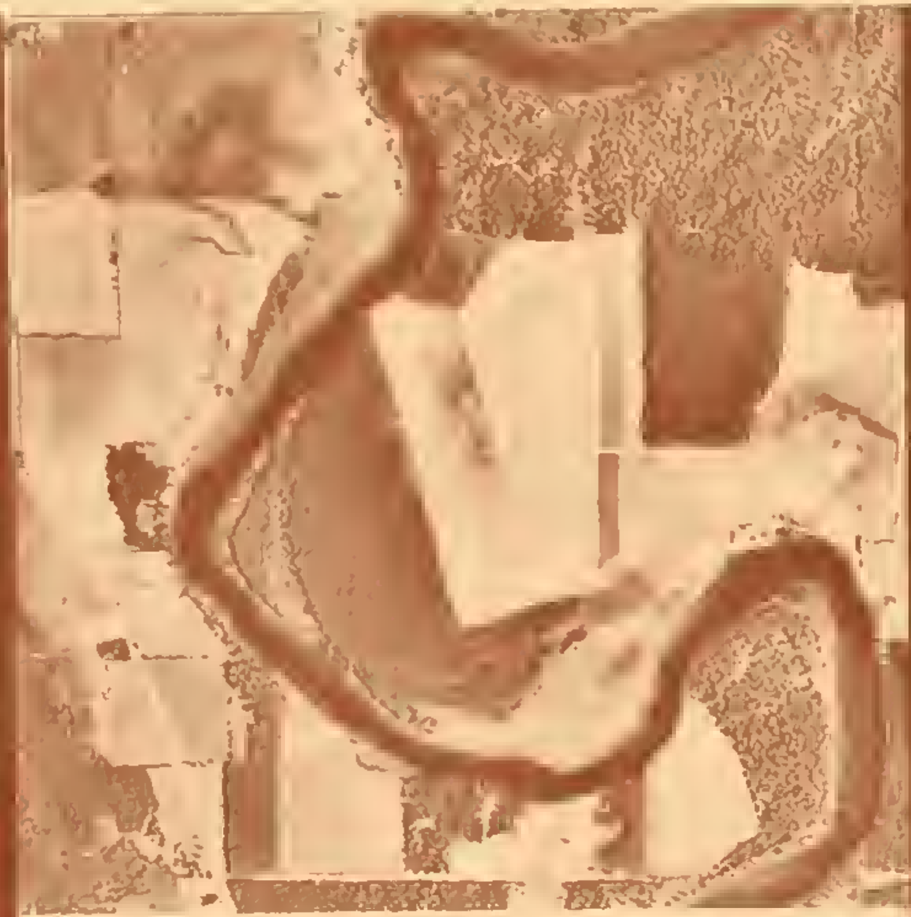
for the same area. False color infrared photos at a scale at least as large as 1:20,000 are recommended for general interpretive purposes. Flight lines must be carefully plotted on a topographic map to insure complete stereoscopic coverage of the entire area.

Timing of photography should depend on the resource inventory objectives as well as the elevation, climate and geography of the planning unit. For example, some hydrological features such as flood plains are more apparent in the spring just after snowmelt. The infrared photography used in this study was obtained during flights in mid-September, a period of maximum vegetative moisture stress. This timing proved to be advantageous for vegetative as well as other resource interpretations.

Photography for most areas in Montana has already been completed at various scales. The Information Systems Bureau of the Department of Intergovernmental Relations in Helena can provide assistance in ordering satellite photo coverage for Montana. Aerial photographs may be ordered from the Agricultural Stabilization and Conservation Service, the U. S. Forest Service, and the National Aeronautics and Space Administration (NASA) at Sioux Falls, South Dakota. Flight indices available from these agencies should be studied to determine if additional photographs are needed.

Section 28, Scale. 4"/Mile,
Soil Conservation Service, 1937

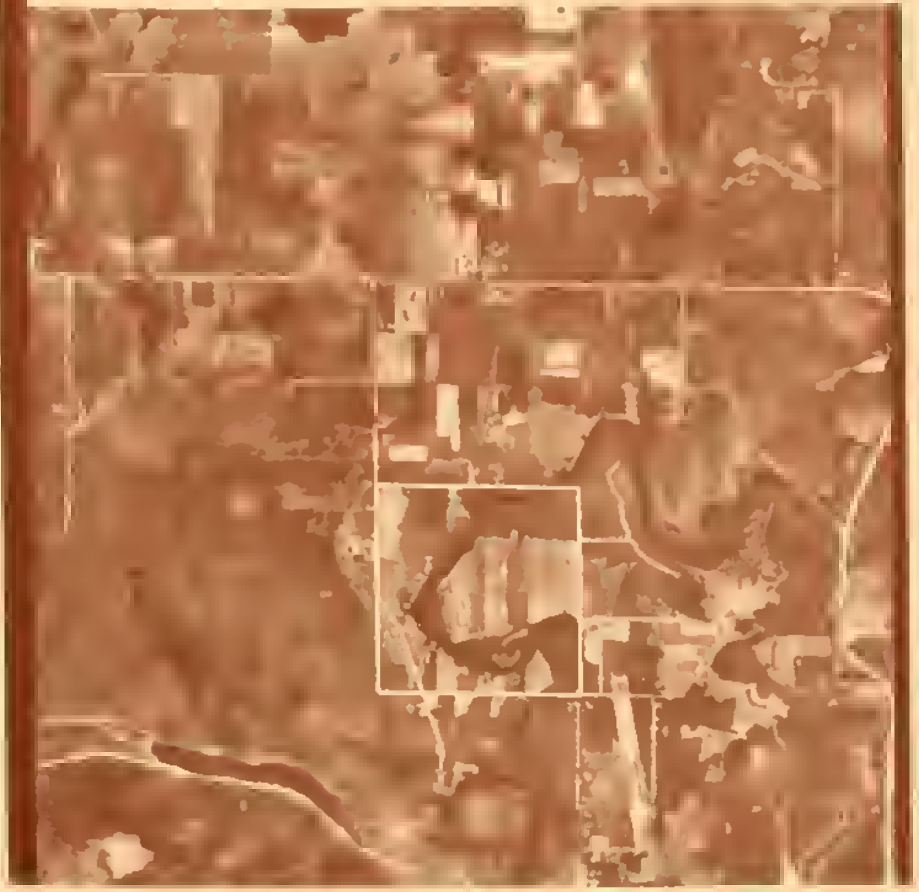


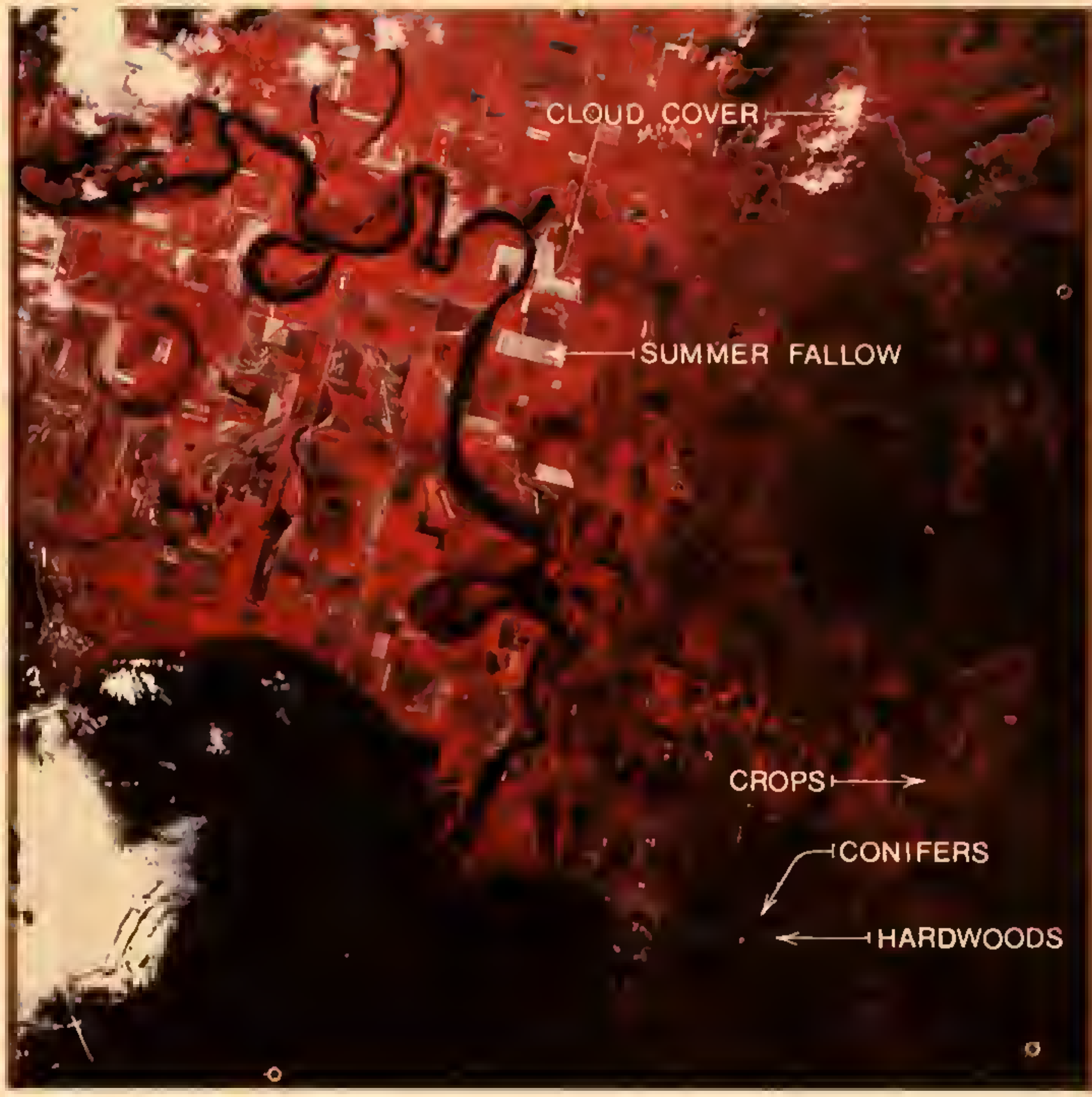


Section 28, Scale 4"/Mile, Agricultural Stabilization and Conservation Service, 1961

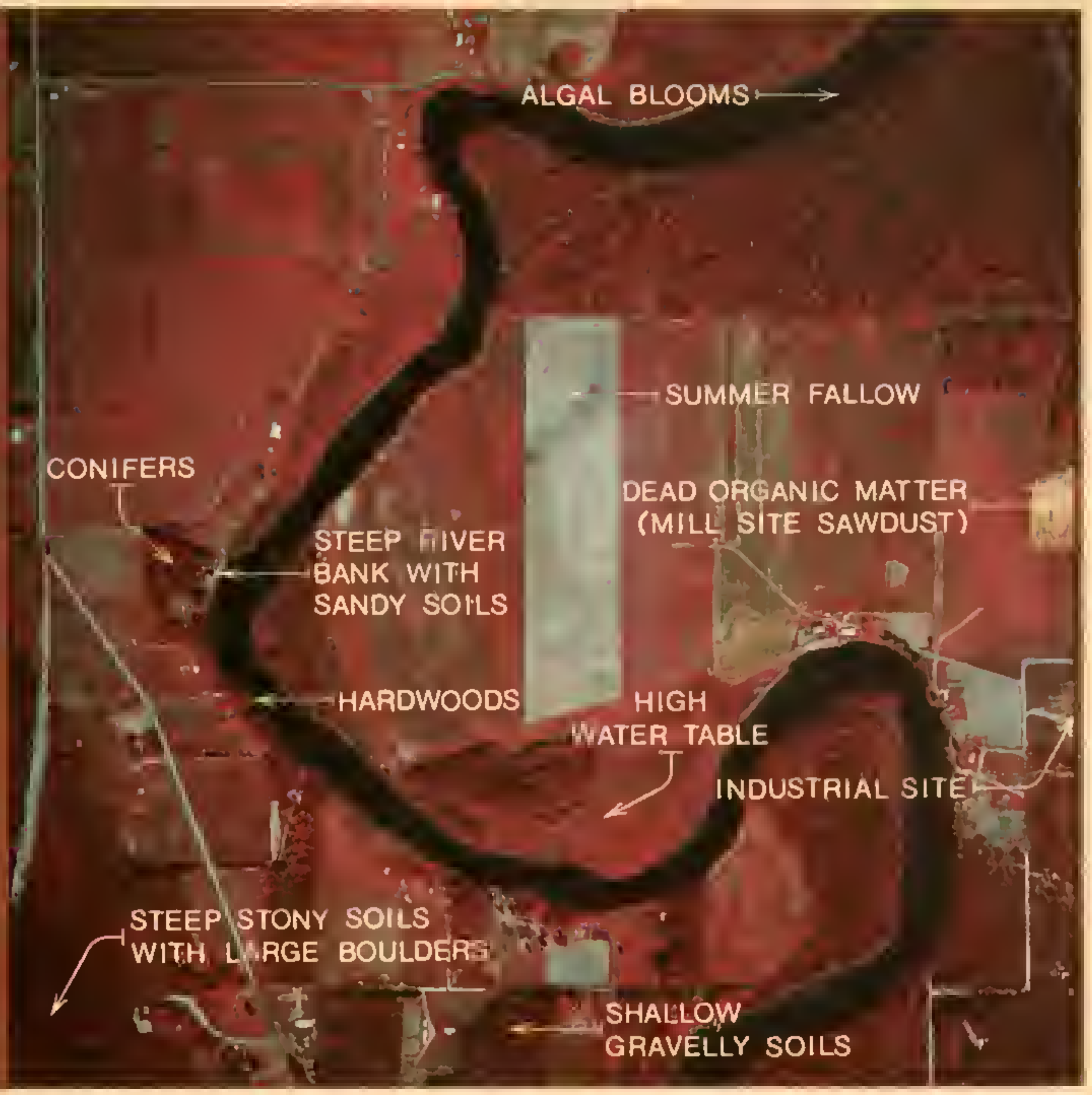
Land use changes as reflected by vegetative clearing may be compared in Section 28 from 1937 to 1971. Interesting vegetation comparisons may also be made between the 1961 black and white photo and the infrared photos on the opposite page.

Section 28 Outlined in Center, Scale. ⅞" Mile, U. S. Forest Service, 1971



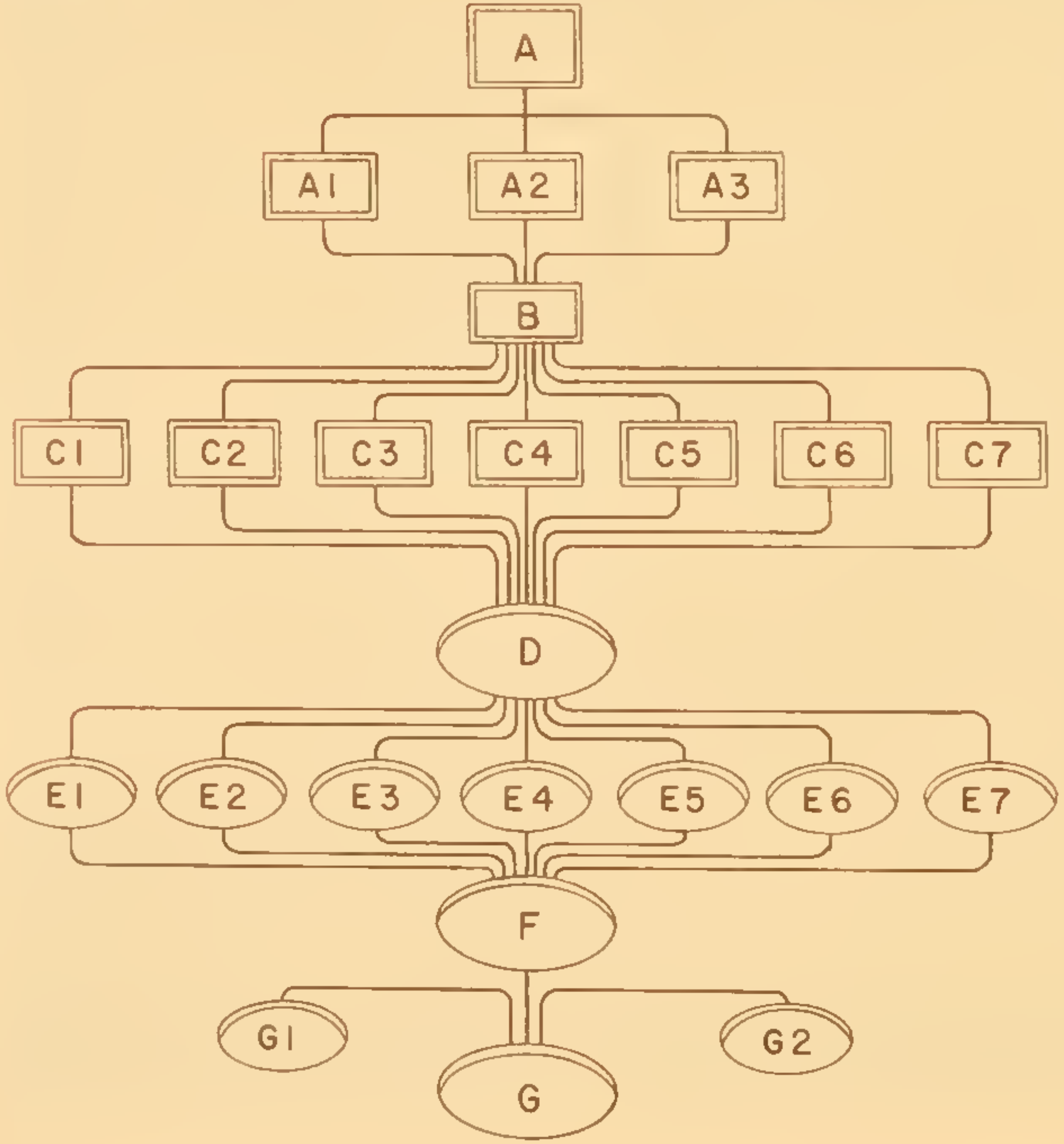


Study Area in Lower Right Portion of False Color Infrared Photograph, Scale, 1/125,000, National Aeronautics and Space Administration, July 1972


ALGAL BLOOMS
SUMMER FALLOW
CONIFERS
DEAD ORGANIC MATTER (MILL SITE SAWDUST)
STEEP RIVER BANK WITH SANDY SOILS
HARDWOODS
HIGH WATER TABLE
INDUSTRIAL SITE
STEEP STONY SOILS WITH LARGE BOULDERS
SHALLOW GRAVELLY SOILS

False Color Infrared Photo of Section 28, Scale, 1/12,000, Montana Department of Natural Resources and Conservation, September, 1972

Diagram and Outline of Method



INVENTORY

A. Selection of Planning area
  1. Survey ownership
  2. Survey land use
  3. Inventory historical values

B. Area description

C. Inventory of natural resources
  1. Geology
  2. Climate
  3. Hydrology
  4. Soils
  5. Vegetation

  Capability Factors

  6. Wildlife
  7. Visual/recreation

  Suitability Factors

INTERPRETATION

D. Broad interpretation to reveal key resource attributes for planning.

E. Production of interpretive maps for each major natural and cultural resource.

F. Determination of broad capability classes based on anticipated tolerance of different landform units to critical impact.

ANALYSIS

G. Synthesis of data into land use capability and suitability composite maps.
  1. Integrate data based on interrelationships between resources.
  2. Establish system for evaluating capability and suitability of land units for various uses.

CONCLUSIONS

The natural resource inventory is not, in itself, a plan. The inventory will provide information relative to supply, but the question of demand must also be addressed in order to realize plan objectives. However, reliable natural resource data converted into a description of land capability for various uses is an essential foundation of any land use plan. This information is also needed in order to develop the rationale for plan implementation.

Natural resource analysis is one segment of a continuous planning process. The inventory method presented in this report is designed to facilitate the process by providing a means of considering natural qualities thought to be of value for a wide range of purposes.

Man and the natural environment are inseparable, and any ecological approach to natural resource analysis must accept man as a vital component. Therefore, a question exists as to what extent it is possible to analyze physical characteristics in isolation from economic and social evaluation, as was done in this study. The problems of value identification and social and economic analysis that are central to resource planning and allocation remain for a more inclusive process, and accordingly this study is not comprehensive in all aspects. The identification of both long and short-range planning goals that reflect changing public desires is a prerequisite to defining the types and detail of physical data needed for a sound plan.

The selection of data most useful to natural resouce analysis and the classification and evaluation of this information are important steps. The data characteristics used in this study are not necessarily applicable to other regions of Montana, nor is a "laundry list" approach recommended as a means of simplifying the complexity of natural processes. A list of resource considerations which are generally applicable is shown in Appendix D, but local modification will be needed.

The key to a good land analysis method is the integration of environmental information, which requires an interdisciplinary approach. An extensive survey of many resource inventory methods has shown that components of the ecosystem are often analyzed individually with only minimal consideration given to interrelationships between resources. This study deals with ecological interactions for purposes of broad-level planning, but further research is needed to refine the integration of data to more accurately reflect ongoing natural processes.

Although the importance of using existing natural resource information cannot be over-emphasized, available data may be inadequate for determining land use capability. This is, in part, a reflection of the different goals of various resource agencies. In acquiring data for this inventory, the following conclusions were made: (1) Considerable quantities of data are being gathered unilaterally by various public and private agencies. (2) Overlap in information is common. (3) Wide arrays of data forms, classification systems and mapping scales are used. (4) Interrelating data from different sources is difficult. (5) A common data-handling system is badly needed.

It is important to recognize limitations of data reliability so that land use recommendations and decisions realistically reflect natural values and processes. If existing information and interpretive assistance from agency personnel are available, an individual with a natural resources background should be able to coordinate the inventory. However, in specialized areas where the data gaps are most pronounced, consultants may be essential if reliable information is to be obtained for planning. In this study professional consultants were retained in the resource fields of environmental geology, groundwater hydrology, climate and wildlife.

Because of interrelationships between resources, all specialists employed should spend some time in the field together. The essential multi-disciplinary approach cannot be achieved in a piecemeal fashion.

The natural resource inventory offers an excellent opportunity for meaningful citizen participation, and often the best information on land use, ownership, natural hazards, wildlife and climate may be obtained from local people. The benefits of economy, more complete and reliable information, and better local identification with planning will result from an honest and open working relationship with the public.

This study has not produced a unique and innovative environmental inventory method for land use planning which may be uniformly applied anywhere in the state. Even if such an all-encompassing approach had been attempted, the wide diversity of natural and social conditions in Montana would have made the result unrealistic.

Rather, the ideas, methods and suggestions of many previous investigators and natural resource specialists have been synthesized into a set of procedures which will hopefully indicate a starting point for those involved in supplying the natural resource element of the comprehensive plan. The techniques and suggestions contained herein will hopefully help stimulate dialogue and interest in necessary local modification of the method for each area in Montana.

APPLICATION

The inventory procedures in this study have been developed with two potential applications in mind: (1) at the local level, as a basis for the comprehensive plan; and (2) at the state level, as a means of identifying and planning for areas of critical environmental concern.

In neither should it be presumed that applying these procedures to land use planning will solve all problems. Their real value will hopefully be in elevating natural resource considerations to the same level as social, economic and political demands in land use decision-making.

While emphasis has been placed on natural resource inventory for comprehensive planning this report should also have application to any public or private agency with an interest in land use planning.

At the local level of application lie the greatest chances for successes or failures. States have delegated to local governments the primary responsibility in planning for the use of private lands and controlling their development. Indeed, most land use decisions are of a local nature, affecting only the residents of the jurisdiction making the decision.

Although there is tremendous need for the inclusion of environmental information in the decision-making process, the commitment and resources to do so must exist.

Natural capabilities and limitations should be properly expressed in the comprehensive plan and in the land use controls which reflect the goals of that plan. If a locality desires to protect natural qualities thorough consideration must be given to physical impacts upon the landscape before massive development is allowed.

The very real limitations of finances, time and expertise must be mentioned. The issue is whether local planning boards comprised of laymen, are capable of natural resource inventory, interpretation and mapping. Few counties in Montana have professional planning staffs, and, in those that do, most of their time is devoted to addressing immediate problems.

In many cases special guidance will be needed in the form of seminars, additional staff specialists, or consultants skilled in the application of natural resource data to land use planning.

However, this need can be greatly reduced if the inventory proceeds from a definition of goals reflecting the needs and desires of local citizens. By identifying specific informational needs, the planning agency may be able to obtain planning interpretations of the data supplied by various agencies.

As growth continues, funds will probably never be sufficient for complete environmental studies. A possible application for the procedures utilized in this study would be to conduct a broad "overview" inventory in order to identify the most critical areas for more intensive study. The level of detail presented in this report is suitable for a small, critical planning unit in a given county, but the procedures used can be adapted to any level from state-wide inventory to actual site studies.

Complex data must be interpreted in a meaningful form for planning and communicated to the public in an interesting way if natural resource considerations are to influence land use decisions. The resource interpretations offered in this study are merely suggestions which can certainly be improved. Maps and other visual aids, generated as a result of the inventory, can be excellent informational devices for meetings and the media in order to gain public support for planning. This support is essential if the governing body is to make decisions responsive to the plan.

The resource inventory can help avoid land use conflicts by identifying resources and presenting usable information for public discussions at an early stage. Early application of the inventory will aid not only the decision-makers but also developers by providing for them a single source of initial information before substantial investments are made in property and planning consultants.

The procedures embodied in this report may also be used in the identification of land resources and land uses with state-wide or regional importance. Examples include natural wetlands, delicate shorelands, flood plains and developments with multi-jurisdictional impacts.

It is hoped that this report may assist in the development of a state-wide land resources inventory. The acceptance of this natural resource inventory method is difficult to predict. Several presentations were made with county commissioners, conservation districts, planning boards, planners and the public, and considerable interest has been expressed. However, the test will be in the application.

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APPENDIX A: GLOSSARY

GENERAL

Ecosystem — the complex of a community of organisms and its controlling environment interacting with each other and functioning as an integrated unit.

Environmentally Critical Area — a specially designated area where uncontrolled development could result in irreversible damage to important cultural values, or could seriously endanger life and property as a result of natural hazards.

Land Capability — an expression of the effect of physical land conditions on the intrinsic capability for use without damage for activities that require land disturbances such as clearing, excavation and imposition of impervious surfaces.

Land Suitability — an expression of the living quality of the environment which includes such intangible values as open space, wildlife, aesthetics and history in relationship to use without impairment.

LAND USE

Agricultural — primarily used for the production of farm commodities and often indicated by symmetrical landscape patterns caused by mechanized equipment.

Barren Land — limited ability to support life and little or no vegetation.

Forestland — at least ten per cent stocked by trees capable of producing timber or other wood products and of influencing climate or hydrology.

Mineral and Energy Production Areas — electric generation facilities and surface and subsurface mining operations, such as sand and gravel pits, quarries and strip-mined areas.

Rangeland — potential natural vegetation is predominantly grasses, grasslike plants, forbs or shrubs.

Scattered, Built-up — developments along transportation routes, smaller towns, and built-up areas where separate land uses may not be distinguishable.

Transportation, Communication and Utilities Corridors — highways, including interchanges, limited access rights-of-way, and service facilities; railroad lines and facilities; and communications and utilities areas.

Urban — areas of intensive use with much of the land covered by structures for residential, commercial and industrial uses.

Water Areas — predominantly or presistently water covered.

GEOLOGY

Alluvial Fan — cone-shaped deposit of sediment made by a mountain stream where it flows onto a level plain.

Cirque — deep, steep-walled recess in a mountain, caused by glacial erosion.

Fluvioglacial — pertaining to streams flowing from glaciers or to the deposits made by such streams.

Glacial Drift — sediment deposited by glaciers.

Glacial Striation — fine-cut lines inscribed by overriding ice on the surface of bedrock.

Lacustrine — produced by or belonging to lakes.

Outwash — drift deposited by meltwater streams beyond active glacier ice.

Pleistocene — the earlier of the two epochs comprising the Quaternary period.

Precambrian Basement Rock — Undifferentiated quartzites and argilites of the Ravalli Group.

Quaternary Alluvium — stream deposited sand, silt and gravel, and swamp deposited peat.

Quaternary Dune Sand — wind deposited dune sand.

Quaternary Glacial Lake — deposits of well bedded and sorted sand, silt and clay; locally overlies kame and till sediments and occasionally overlain by sand dune deposits.

Quaternary Glacial Undifferentiated — kame, crevasse and moraine deposits of well to poorly bedded and sorted sand, silt, gravel and boulders.

Quaternary Unstable Slope — loose rock deposits formed by the processes of landslide and talus creep.

Ripple Marks — undulating surface sculpture produced in granular materials by the wind or by currents of water.

Seiche — fluctuation in the surface of a lake caused by an earthquake.

Seismic Risk — amplitude of ground motion for an earthquake of given magnitude. Risk is highest on unconsolidated material.

Till — nonsorted sediment carried or deposited by a glacier.

Varve — sedimentary bed deposited within one year's time.

CLIMATE

Aspect — slope orientation to the sun.

Evapotranspiration — water loss through evaporation (from soil and surface water bodies) and transpiration (from plants).

Temperature Inversion — increase (instead of the usual decrease) of air temperature with increase in elevation.

HYDROLOGY

Aquifer — body of permeable sediment or rock through which ground water can move; may or may not yield ground water in useful quantities.

Artesian — refers to ground water under sufficient pressure to rise above the aquifer containing it.

Flood of 100-year Frequency — A flood magnitude expected to occur on the average once every 100 years.

High Water Profile — elevation of the 100-year flood for a particular reach of stream.

Stream Morphology — structure and forms of a stream system including such features as channel shape, meander patterns and channel slope.

SOILS

AASHO System — a system for classifying the engineering properties of soils based on the American Association of State Highway Officials.

Available Water Capacity — the capacity of a soil to hold water in a form available to plants.

Bearing Strength — load-supporting capacity of a soil.

Frost Action Potential — heaving of soils upon freezing as a result of the formation of ice crystals in the soil.

Permeability — the rate at which water will move downward through a saturated soil.

Soil Drainage — the rate or extent of removal of water from the soil.

Soil Horizon — horizontal layer of soil differing from adjacent layers in physical, chemical and biological properties.

Soil Profile — vertical section of the soil through its horizons extending from the surface into the parent material.

Soil Series — group of soils developed from a particular type of parent material with horizons that are similar in properties and profile arrangement.

Texture — the relative proportions of sand, silt and clay particles in a mass of soil.

VEGETATION

Association — a distinctive combination of two or more plant unions which develops wherever ecologically equivalent habitats occur.

Community — all plant populations of a given area.

Habitat type — term for those areas that support or can support the same plant association.

Relic Stand — unit of trees substantially unaffected by human activities such as logging or roading.

VISUAL

Enclosed Landscape — spaces, such as a meadow, surrounded by continuous groupings of objects.

Ephemeral Landscape — depends on transitory effects such as weather conditions, reflections and animal sightings.

Feature Landscape — dominated by feature objects or groups of feature objects, such as a tree on a treeless plain.

Focal Landscape — series of parallel objects seen in alignment to create a focal effect such as a river gorge.

Panoramic Landscape — little or no sense of boundary restriction, such as rolling prairies.

REMOTE SENSING

Blueline Map — an inexpensive reproduction of an original map using light sensitive paper with an ammonia vapor developing process.

Infrared — pertaining to that portion of the electromagnetic spectrum with wave lengths just beyond the red end of the visible spectrum.

Remote Sensing — acquisition of natural resource information by noncontact methods, usually in the form of photographs taken from airplaines or satellites.

Signature — patterns of color and texture on aerial photography which indicate resource features.

Stereoscopic coverage — aerial flight is planned so that exposures will overlap about 60 per cent of the width along the flight line and about 30 per cent between adjacent flight strips. Any overlapping pair of exposures can be viewed three-dimensionally with an optical device known as a stereoscope.

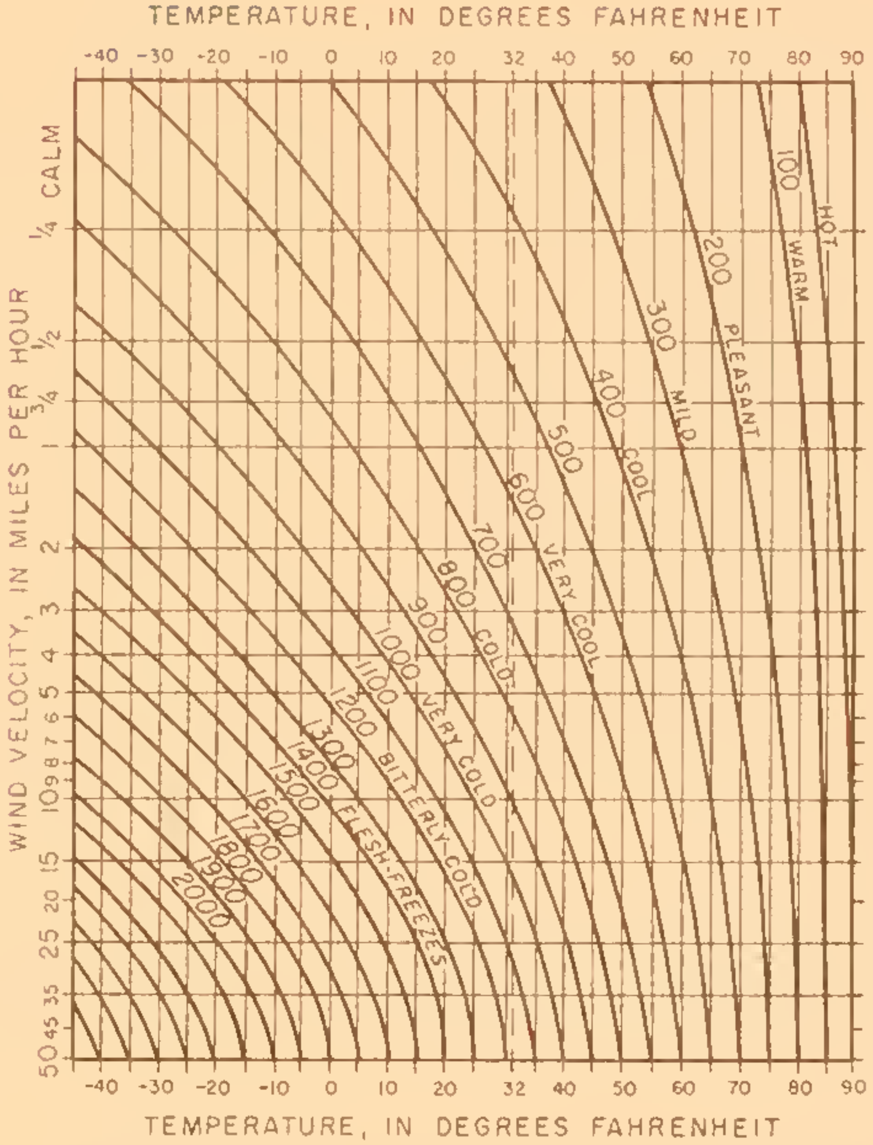
Topographic map — a graphic representation of a small portion of the earth's surface. The configuration of the surface is shown with contour lines that connect points of equal elevation.

APPENDIX B: SOILS AND CLIMATE

Estimated Physical and Chemical Properties of Soils-Bigfork Study Area, Montana 1970

Soil Series & Map Symbols	Depth to: Bedrock, gravel, etc.	Depth to: Seasonal water table	Depth from surface	Classification: USDA Texture	Classification: Unified	Classification: AASHO	Percentage Larger Than 3 Inches	Permeability	Available water capacity	Shrink-swell Potential	Frost Action Potential
	(inches)	(feet)	(inches)					(inches per hour)	(inches per inch of soil)		
Buch (BC)	10 to 20 (gravel)	1 to 10	0 to 14 14 to 60	Fine sandy loam or gravelly loam Sand & gravel	SM GP or SP	A-4 A-2-4 A-1	0 to 1 0 to 3	2.0-6.3 6.3-20	.05-.11 .02-.03	Low Low	Low Low
Blanchard (Bn,Bo,Bp,Br)	60 plus	Below 10	0-18 18 to 60	Fine sand & loamy fine sand Fine sand	SM SP-SM	A-2-4 A-3	0 0	2.0-6.3 6.3-20	.08-.12 .03-.06	Low Low	Moderate Low
Corvallis (Cl)	60 plus	2 to 6	0 to 11 11 to 20 20 to 60	Silty clay loam Silt loam Stratified silt loam & very fine sandy loam	CL CL ML-CL	A-6 A-6 A-4	0 0 0	.2-.63 .2-.63 .63-2.0	.16-.20 .14-.19 .13-.18	Moderate Moderate Low	High High High
Creston (Cr)	60 plus	6 to 12	0 to 18 18 to 60	Silt loam Silt loam & very sandy loam	ML-CL ML-CL	A-4 A-4	0 0	.63-2.0 .63-2.0	.16-.20 .13-.18	Low Low	High High
Flathead (Fa,Fb,Fc)	60 plus	Below 10	0 to 24 24 to 44 44 to 60	Very fine or fine sandy loam Fine sandy loam or loamy fine sand Loamy fine sand	ML ML or SM SM	A-4 A-4 A-2-4	0 0 0	2.0-6.3 2.0-6.3 2.0-6.3	.13-.19 .11-.16 .10-.15	Low Low Low	Moderate Moderate Moderate
Half Moon (Ha,Hb,Hc,Hd)	60 plus	Below 8	0 to 7 7 to 22 22 to 60	Silt loam & very fine sandy loam Silty clay loam Silt loam & very fine sandy loam	ML-CL CL ML	A-4 A-7 A-4	0 0 0	.20-.63 .06-.20 .20-.63	.13-.16 .14-.19 .12-.15	Low Moderate Low	High High High
Haskill (Hk,Hm,Hn,Ho,Hp)	72 plus	Below 10	0 to 27 27 to 32 32 to 72	Fine sand or loamy fine sand Fine sand & loam Fine sand	SM SM SM	A-2-4 A-2-4 A-2-4	0 0 0	2.0-6.3 2.0-6.3 6.3-20	.06-.10 .10-.14 .06-.10	Low Low Low	Low Low Low
Krause (Kzk,Kzm,Kzn,Kzo)	10 to 20 (gravel)	Below 8	0 to 12 12 to 20 20-60	Gravelly loam Very gravelly sandy loam Very gravelly & cobbly sand	GM GM & GW-GP	A-4 A-1 A-1	0-5 0-5 5-20	.63-2.0 2.0-6.3 6.3-20	.12-.15 .06-.10 .03-.04	Low Low Low	Low Low Low
McCaffery (Mb,Mc,Md,Me,Mf)	60 plus	Below 10	0 to 30 30 to 60	Loamy sand Medium sand	SM SP-SM	A-2-4 A-1	0 0	2.0-6.3 6.3-20	.06-.10 .04-.05	Low Low	Low Low
Mires (Mg,Mh,Mk,Mm,Mn)	10-20 (gravel)	Below 12	0 to 8 8-14 14-60	Loam or gravelly loam Gravelly loam Very gravelly loamy sand	ML ML-GM GM-GP	A-4 A-4 A-1	0-2 0-2 0-5	.63-2.0 2.0-6.3 6.3-20	.14-.19 .13-.16 .04-.05	Low Low Low	Moderate Low Low
Muck & Peat	——	0 to 2	24-60	Organic	OH	——	——	2.0-6.3	.20-.40	High shrink low swell	High
Radnor (Ra,Rb)	60 plus	0 to 3	0 to 8 8 to 30 30 to 60	Organic Silty clay loam Silt loam & silty clay loam	OH MH MH or ML	A-7 A-7	0 0	.06-.20 .20-.63	.14-.18 .14-.17	Moderate Moderate	High High
Selle (Sh,Si)	60 plus	Below 10	0 to 36 36 to 60	Fine sandy loam Loamy fine sand	ML or SM SM	A-4 A-2-4	0 0	.63-2.0 2.0-6.3	.12-.14 .08-.12	Low Low	Moderate Moderate
Stryker (Sk,Sm,Sn)	60 plus	2 to 7	0 to 9 9 to 22 22 to 60	Silt loam or silty clay loam Silty clay loam Silty & fine sand	ML-CL ML-CL ML	A-6 A-7 A-4	0 0 0	.20-.63 .06-.20 .63-2.0	.15-.18 .13-.19 .12-.16	Moderate Moderate Low	High High High
Waits (Wa,Wb,Wd,We,Wf,Wg,Wh,Wk,Wn)	60 plus	Below 8	0 to 26 26 to 60	Cobbly & stony silt loam Gravelly to stony loams	GM or ML GM or ML	A-4 A-4	0-20 5-20	.63-2.0 .63-2.0	.14-.16 .13-.15	Low Low	Moderate Moderate
Whitefish (Wt,Wze,Wzh)	24 to 60	Below 12	0 to 19 19 to 60	Gravelly silt loam Gravelly & stony silt loam	ML or GM GM or ML	A-4 A-4	2-15 5-17	.63-2.0 .63-2.0	.13-.15 .12-.14	Low Low	Moderate Moderate

SOURCE: U. S. Soil Conservation Service. **Engineering Properties and Soil Interpretations for Use in Resource Planning and Development.** July 1970. (34 pp.)



To obtain equivalent windchill temperature, select current temperature value (F) at right side of chart; move horizontally to the left to a point vertically below the current wind velocity (mph); follow to the left and downward to the nearest parallel line until you intersect the ¼ mile per hour vertical line; go back horizontally to the right and read off the equivalent windchill temperature.

Example: At 0°F with a 20 mph wind the equivalent windchill temperature would be -40°F. Curves based upon Paul Siple's index as published in **Quartermaster Research and Engineering Command**, USA Technical Report EP-82, "Windchill in the Northern Hemisphere," Falkowski and Hastings, February 1958.

APPENDIX C: VEGETATION AND RECREATION

HABITAT TYPE		COVER TYPE (common name)	
Common Name	Scientific Name		
Ponderosa pine/idaho fescue	Pinus ponderosa/Festuca idahoensis	Douglas fir	
Ponderosa pine/snowberry	Pinus ponderosa/Symphoricarpos albus	Douglas fir	
Douglas fir/dwarf huckleberry	Pseudotsuga menziesii/Vaccinium caespitosum	Lodgepole pine Western larch Ponderosa pine	
Douglas fir/snowberry	Pseudotsuga menziesii/Symphoricarpos albus	Ponderosa pine Western larch	
Douglas fir/ninebark	Pseudotsuga menziesii/Physocarpus malvaceus	Ponderosa pine Lodgepole pine Western larch	
Douglas fir/twinflower	Pseudotsuga menziesii/Linnaea borealis	Ponderosa pine Lodgepole pine Western larch	
Spruce/twinflower	Picea/Linnaea borealis	Ponderosa pine Douglas fir Western larch Spruce	Lodgepole pine Paper birch Black cottonwood Quaking aspen
Grand fir/queencup beadlily	Abies grandis/Clintonia uniflora	Douglas fir Lodgepole pine Western larch Spruce	Western white pine Western hemlock Paper birch
Western red cedar/queencup beadlily	Thuja plicata/Clintonia uniflora	Douglas fir Lodgepole pine Western larch	Spruce Grand fir Western white pine

Species under the cover types are those found in all or part of the habitat types indicated on the map (p. 45). Habitats under 10 acres in size are not indicated because of the small publication scale.

Bureau of Outdoor Recreation Classification System

Class	Physical Requirements	Location	Activities	Developments	Responsibility
I High Density Recreation Areas	Physiographic features should be adaptable to special types of intensive recreation. Man-made settings are acceptable. There are no specific size criteria.	Usually within urban population centers, but may occur within such units as national parks and forests.	Intensive day or weekend type, such as picnicking.	High degree of facility development which may include a road network, parking areas, bathing beaches and marinas, bathhouses, artificial lakes, playfields, and sanitary and eating facilities.	Commonly held under municipal, county, region or state ownership. Many commercial resorts have similar characteristics.
II General Outdoor Recreation Areas	May have varied topography, interesting flora and fauna within a generally attractive natural or man-made setting adaptable to providing a wide range of opportunities.	Usually more remote than Class I areas, but relatively accessible to urban population. Accommodates a major share of all outdoor recreation. Included are ski areas, resorts and hunting preserves.	Extensive day, weekend and vacation use types such as camping, picnicking, fishing and hunting.	Generally less intensive than Class I areas. Includes, but not limited to, access roads, parking areas, picnic areas and campgrounds. Areas are equipped with some man-made facilities, which may vary from simple to elaborate.	Federal, state or local governments, including regional park and recreation authorities, private clubs and other forms of private ownership.
III Natural Environment Areas	Varied and interesting land forms, lakes, streams, flora and fauna within attractive natural settings.	Usually more remote from population centers than Class I and II areas. Occur throughout the country and on an acreage basis are the largest class in both public and private ownership.	Extensive weekend and vacation types dependent on quality of the natural environment, such as sight-seeing, hiking, nature study, camping, swimming, canoeing, and mountaineering.	Access road, trails, picnic and campsite facilities and minimum sanitary facilities. There may be other compatible uses of the area such as watershed protection, grazing, lumbering and mining.	Federal, state or local governments, including regional park and recreation authorities and private ownership.
IV Outstanding Natural Areas	Outstanding natural features associated with an outdoor environment that merit special attention and care in management to insure their preservation in their natural condition. Includes individual areas of remarkable natural wonder, high scenic splendor, or scientific importance.	Any place where such features are found.	Sightseeing, enjoyment and study of the natural attractions so as to preserve the quality of the natural features.	Limited to minimum development required for protection of the features and public enjoyment, health and safety. Improvements should harmonize with and not detract from the natural setting.	Public agencies (federal, state and local) and private landowners with assistance from public agencies, who may identify, set aside, and manage natural features.
V Primitive Areas	Extensive wild and undeveloped area and setting removed from the sights, sounds and smells of civilization. Natural environment has not been disturbed by commercial utilization, and the areas are without mechanized transportation.	Usually remote from population centers.	Camping out on one's own without mechanized transportation, permanent shelter or other conveniences.	No development of public roads, permanent habitations or recreation facilities except trails. No mechanized equipment allowed except that needed to control fire, insects and disease. Commercial use of the area that may exist at the time of establishment should be discontinued as soon as practical.	Usually federal but may also be by state agencies or private landowners (such as the high mountain country held by large timber and mining companies.)
VI Historical Cultural Sites	Associated with the history, tradition or cultural heritage of national, state or local interest and are of enough significance to merit preservation or restoration.	The location of the feature establishes the site.	Sightseeing, enjoyment and study of the historical cultural features. Kinds and intensity of use limited to this type of study and enjoyment.	Management should be limited to activities that would effect such preservation and restoration as may be necessary to protect the features from deterioration and to interpret their significance to the public.	Public agencies (federal, state, and local) and private landowners who identify, set aside, and manage historical and cultural areas.

APPENDIX D: NATURAL QUALITIES

1. **Geology**
   - Bedrock geology
   - Features of unique scientific and educational value
   - Geologic resources
   - Geologic hazard
     - major fault — location and frequency
     - minor fault — fault traces and
     - landslides — fault zones
   - Seismic response
   - Slope stability
   - Potential settlement
   - Degree of weathering
   - Strength of geological foundations
   - Stream cutting
   - Ease of excavation
   - Long term fluvial movements
   - Physiography
     - general topography
     - landforms - limitations and capabilities
     - Slope — contours
     - slope aspect
   - Elevation
     - slope
     - aspect
     - elevation above ground water
     - snow depth, frequency and duration
     - temperature and wind

2. **Climate**
   - Storm paths (snowbelts)
   - Average annual temperature
   - Temperature extremes
   - Precipitation — rainfall, snow
   - Climatic exposure
   - Wind — pattern, direction and velocity
   - Inversions
   - Solar elevation

3. **Hydrology**
   - Ground water
     - aquifers
     - aquifer recharge zones
     - depth to ground water
   - Surface water
     - swamps
     - high and low water marks of all lakes and streams showing the 100 year flood plain
     - water quality
     - watersheds for stream quality protection ranked according to scenic value
     - streams rated according to stability
     - ditches, aqueducts and dams
     - irrigation systems

4. **Soils**
   - Soil depth
     - shallow
     - moderate
     - deep
   - Water holding capacity
     - high
     - moderate
     - low
   - Surface permeability
     - slow
     - moderate
     - rapid
   - Subsurface permeability
     - slow
     - moderate
     - rapid
   - Shrink-swell behavior
     - high
     - moderate
     - low
   - Erosion hazard — relate to soil type and steepness of slope
     - low
     - moderate
     - high
   - Limitations for on-site sewage disposal, roads and residential use
     - slight
     - moderate
     - severe
   - Foundation conditions
     - rate compressive strength and stability of soil types
   - Slope stability
   - Agricultural capability

5. **Vegetation**
   - Present plant communities — forest, marsh, cultivated land description, composition and density of dominant overstory and understory plant species
     - plant community tolerances for physical and chemical disturbances
     - determine plant successional trends based on existing management practices such as fire exclusion
     - estimate potential changes in succession that would follow new management practices and/or physical development impacts, i.e., irrigation, soil compaction
     - habitat types - potential vegetation
     - relic plant communities

6. **Wildlife**
   - Type and abundance of field and forest species
   - Type and abundance of water-associated species
   - General habitat and areal requirements, i.e., winter range, migratory routes, limiting factors associated with each species
   - Identify population and migration pattern changes that could be associated with various land use alterations
   - Fishery spawning beds

7. **Visual resources**
   - Flora
   - Fauna
   - Water
   - Color, hue
   - Color, value
   - Form
   - Spatial definition
   - Light direction
   - Distance
   - Observer Position
   - Continuity
   - Harmony
   - Discord
   - Repetition
   - Landscape types
     - panoramic
     - feature
     - enclosed
     - focal
     - detail
     - ephemeral
   - Landscape features
     - major
     - minor
   - Problem areas

8. **Recreation**
   - Classify planning area
     - high density areas
     - general outdoor recreation areas
     - natural environment areas
     - outstanding natural areas
     - primitive areas
     - historical and cultural sites
   - Critical travel zones
   - Use zones
     - day
     - weekend
   - Primary and secondary nodes of interest

Log Hauling in the Early 1900's

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